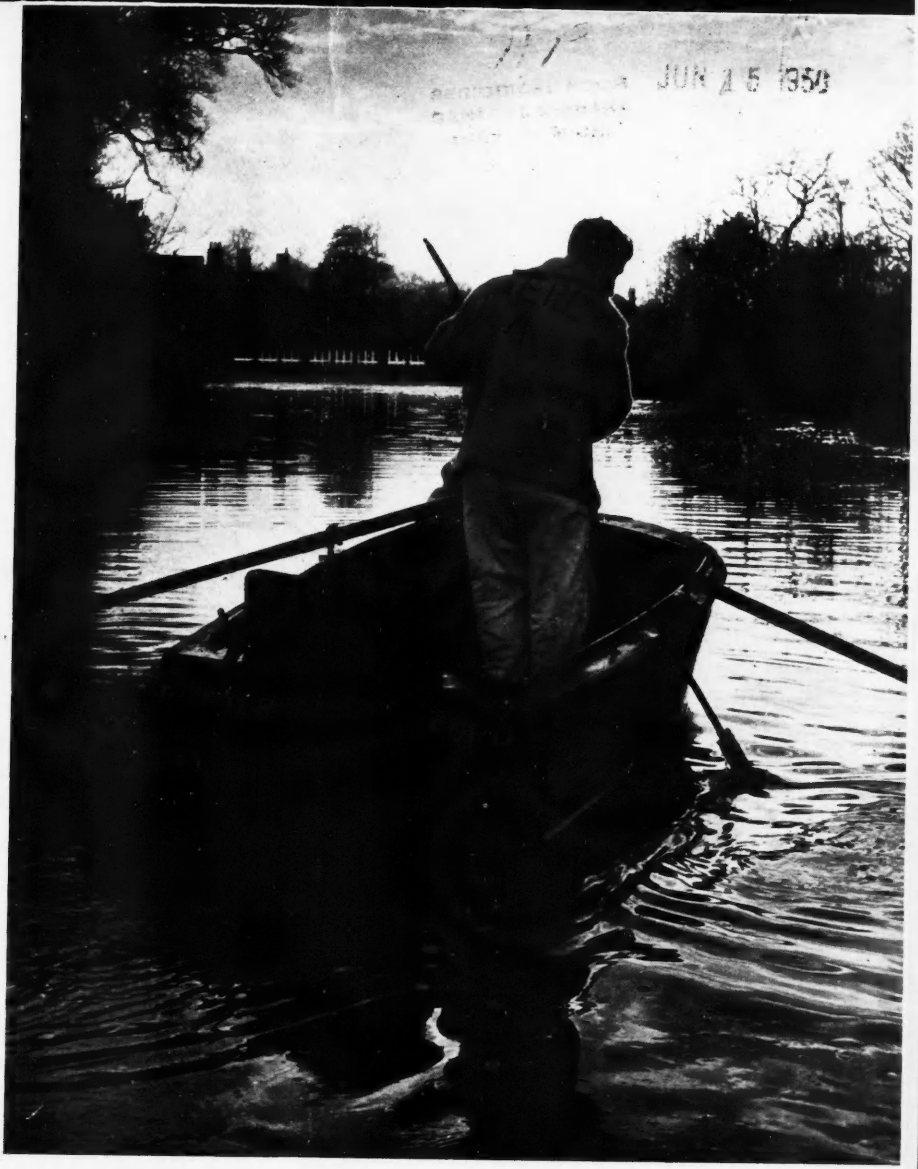
DISCOVERY



JUNE

1950

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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

June, 1950 Vol. XI. No. 6

Editor WILLIAM E. DICK, B.Sc., F.L.S.
Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Advertisement Office: Temple Chambers, Temple Avenue, London, E.C.4. Tel. City 6537 (Three Lines)
All Subscriptions, Distribution and Business Communications to Jarrold & Sons Ltd., Norwich. Tel. Norwich 25261

The Progress of Science

Science and the Groundnut Scheme

At a recent meeting of the Parliamentary and Scientific Committee, Dr. A. H. Bunting, who left Rothamsted to take charge of the scientific side of the groundnut scheme, gave an account of the research work which he and his team have been doing. He explained how the Overseas Food Corporation established its Scientific Department three years ago. Today there is in Tanganyika a headquarters organisation of specialists in soils, entomology, crop botany, statistics and chemistry. The headquarters team, which has a central chemical, biological and statistical laboratory, is supported in each of the three regions by junior officers on the staffs of the regional experimental farms. Each of these farms is of 700 acres or over and is fully mechanised. Its staff includes a manager, a fitter or engineer, a junior agronomist, pathologist and soil chemist.

Pilot scale experiments are being made to discover which techniques of cultivation are most economical. Ploughing for the purpose of turning over the soil as is done in Britain is not justified except in so far as it is done to prevent the formation of a hard pan below the surface. The soils of Tanganyika are very permeable, and it only seems necessary to prepare a good seed-bed, for which purpose the disc harrow is ideal. Annual ploughing in Britain destroys the mat of weeds that grow in autumn and winter; the prolonged dry season in Tanganyika does not favour weeds and reduces the importance of this operation. The pilot scale experiments are being done on 10-acre plots, full costings being kept for each plot. One experiment can occupy four to eight plots.

One type of scientific expert entirely lacking from the groundnut scheme is the plant breeder. Dr. Bunting said this was the most serious deficiency in his team at present. Apparently great efforts have been made to rectify this, but without success. Dr. Bunting underlined this point by saying that while Britain is in a magnificent position (because of the excellent schools of genetics existing in Britain) to develop a major school of practical plant breeders, there are at present only a handful of trained and experienced breeders at work in Britain, let alone in the tropics.

Plant diseases have so far caused little trouble. Indeed the only really serious disease the scheme has encountered so far is the rosette disease of groundnuts, caused by a virus, and Dr. Bunting expressed a belief that an efficient method of controlling it is in sight. The rumour that groundnut growing at Urambo would have to be abandoned because of the disease had no foundation. One insect pest (*Calidea dregei*), a natural inhabitant of the bush, which ruined attempts to grow cotton in certain parts of Tanganyika, had attacked the sunflower crops. Pyrethrum, gammexane and DDT had proved ineffective, but a good armoury of the newer insecticides would be used against the pest this year.

An Operational Research Unit to investigate the efficiency of agricultural equipment used on the scheme was set up a year ago. This unit has now extended its field of activity in order to study the problems of large-scale agricultural work. Briefly, the problem is this. On the experimental farms groundnut yields of 1000 to 1500 lb. per acre are often achieved, sunflower yields of 1200 lb. are not unusual, and maize and sorghum yields may pass 1 ton an acre. Yet, on the large scale these results are not even approached. Partly this is because the soils of the experimental farms are from the first more thoroughly prepared and represent the conditions which obtain on the units only in the second or third year. But in general the differences arise from the difficulties of operating with high efficiency and skill on tens of thousands of acres; and these difficulties, Dr. Bunting believes, must at least be greatly reduced by operational studies. The Scientific Department carries its studies to the costings stage, on individual plots of pilot or 10-acre size; and at this point the Operational Research Unit takes over selected questions and carries them—with the Scientific Department's collaboration—to the square mile and 10,000-acre level.

Dr. Bunting emphasised that the findings of the scientists on the groundnut scheme should be valuable outside Tanganyika, for they offer solutions to the general problems of semi-arid tropical farming as a whole. In view of the fact that East and Central Africa seems likely to become the scene of major agricultural development to meet expanding world food needs, the importance of the scientists' part in the groundnut scheme cannot be overestimated.

Calories are not Enough

One of the first statements the new Minister of Food made was that he was going to talk about food and not about calories. This was a welcome change and, we pray, a hopeful portent. Calories are of vital importance in war-time but the carrying over of the calorie outlook to our food problems in peace-time, though doubtless desirable in the inner councils of the Ministry, only bored and annoyed the general public. The man in the street got no kick out of official announcements that we were getting 50 or 100 calories more than in war-time. What mattered was that we were getting what was substantially a war-time diet with all its lack of variety for years after the war had ended and for years, some people contended, after it was necessary. One must not minimise the importance of the work the Ministry of Food has performed during and since the war in keeping a minimum standard of nutrition for everybody whether they be rich or poor, but to quote calorie levels as an index of how well fed we were was no compensation for the boredom of the diet. How wrong the attitude of the Ministry of Food was to the all-important question of variety in diet was revealed by Dr. Edith Summerskill in reply to a question in the House of Commons as to whether something could not be done about the awful mousetrap cheese which constituted our ration and whether it would not be possible to bring back some of those beautiful English pre-war cheeses. Dr. Summerskill's reply to this was that she saw no reason for pandering to acquired tastes—thus she exhibited a complete ignorance of the psychological aspects of diet. The Ministry under Mr. Strachey and his Parliamentary Secretary was much too smug about its policy since the war. It allowed itself to be dragged into debates in the House on how many calories we were getting. What did it matter whether we were 100 calories up, as the Minister maintained, or 100 calories down, as the opposition, both medical and political, claimed? In a survey conducted by the Ministry of Health, wide variations in calorie intake were found even among sedentary workers; figures varying from 1800 to 2600 were found for different individuals by direct estimation of food intake. But when one takes into account as well the Ministry's method of estimating calories based on theoretical calculations, and without taking into proper account the wastage involved in distribution and cooking, the quotation of a calorie figure as being up or down by 100 or 200 calories as an index of the state of our nutrition, is even more meaningless.

The time has come, as Mr. Maurice Webb has said, to talk about food and not about calories—Marie Lloyd's music hall dictum of "a little of what you fancy does you good" is as true today as ever it was.

The Electronic Telescope

In French astronomical circles there is talk of an 'electronic telescope', a phrase which immediately suggests a number of interesting speculations. So far there does not seem to have been an account of this work in English, though from an account in the French journal *Sciences et Avenir*, which gives a description of the instrument, we gather that it is either actually in operation or in a very advanced state of development.

The limiting faintness of a point object visible or capable of being photographed by means of an ordinary large telescope depends on the diameter of the mirror. We may regard the mirror of a reflecting telescope as a collector of light from a point object such as a star. The amount collected is, apart from losses due to imperfections in the mirror as a reflector, the total light falling on the mirror. For a point object, all this light is packed into what is effectively a point image. For an extended object, such as a nebula, a second factor is of importance: now the collected light is not packed into a single point but into an extended image, the scale of which depends on the focal length of the telescope.

In astronomical photography one almost never has as much light as one wants. Always the faintest and most interesting objects are so faint that the density of the images on the photographic plate is less than one would like it to be. One way of improving this situation is to make the mirror bigger. Doubling the size of the main mirror of a telescope quadruples the light available for forming the image of a star. However, if in doubling the mirror diameter one also doubles the focal length, i.e. if one merely constructs the same telescope with all the dimensions doubled, the image of a nebula is also doubled in size, and the light intensity in the image is not increased.

The idea of the electronic telescope as described in *Sciences et Avenir* represents a most interesting conjunction of a number of lines of research. It partakes first of the principle of the type of night vision apparatus greatly developed by the Germans for use by snipers. This equipment, already described in Discovery (May 1946), used infra-red radiation to form an invisible image on a screen, electrons from which were accelerated in vacuo to form a similar but more intense image in visible light on a second fluorescent screen. The electronic telescope also has an affinity with the electron microscope, and clearly embodies a great deal of modern vacuum and high-tension technique.

The image of the object viewed is formed by a telescope in the ordinary way, but, instead of putting a photographic plate there to record it, a vacuum tube, carrying on its inner face a thin layer of caesium, is placed in the position normally occupied by the photographic plate. The luminous parts of the image cause the ejection of electrons from the caesium into the vacuum tube. In effect a 'luminous' picture of part of the sky is formed which emits not light but electrons. These electrons can be rendered more energetic by putting two electrodes into the tube and applying an electrostatic potential between them—the figure of 50,000 volts is quoted. To re-form the picture a magnetic lens is used. This, a device much developed in connexion with the electron microscope, is a coil of special design so constructed that all the electrons emitted from a point of the original picture formed on the caesium layer impinge together at a corresponding point on a photographic plate put in the vacuum to receive the electrons. These electrons produce blackening of the plate where they impinge on it. Clearly, if more blackening is produced on the plate with this arrangement than on a plate in the normal focus position of the telescope, then a gain will have been secured.

The question whether there will be a gain or not depends on the construction. One difficulty is that the caesium layer must be thick enough to allow the incident photons to interact with the metal, but on the other hand it must be

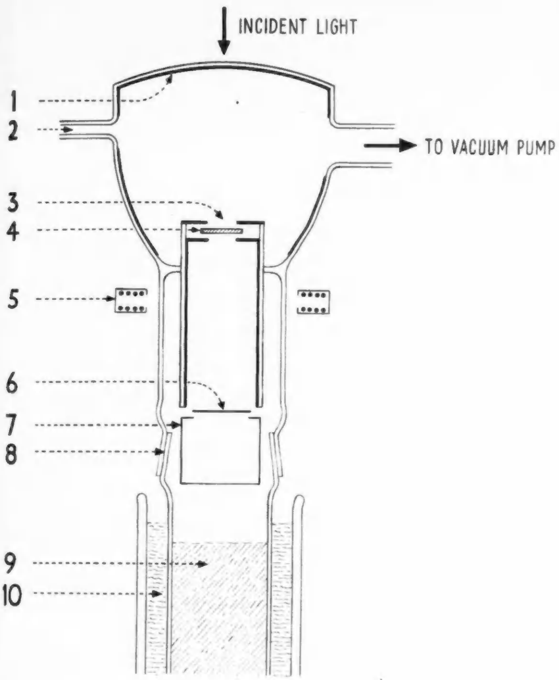


IMAGE CONVERTOR FOR ELECTRONIC TELESCOPE

1. *Photo-sensitive caesium layer (photocathode) which is semi-transparent.*
2. *Tube through which caesium is introduced when sensitising the photocathode.*
3. *Accelerating electron lens.*
4. *The aperture for isolating the photocathode during sensitising process is actuated by external magnet.*
5. *Magnetic lens for focusing.*
6. *Shutter actuated by magnet.*
7. *Magazine for photographic plates, and fluorescent screen for focusing.*
8. *Air-tight joint.*
9. *Drying agent.*
10. *Liquid air.*

sufficiently thin to allow the electrons to be discharged into the evacuated space. This is a point of difference from most photoelectric equipment in which the light falls on a surface and the electrons are liberated on the same side as the incident light. The figure quoted for existing equipment (with hope of future improvement) is that 100 photons are necessary to cause the ejection of one photoelectron. This emitted electron, accelerated by a potential difference of 50,000 volts, is then capable alone, having passed through the magnetic lens and having arrived at the photographic plate, of causing the reduction of one silver grain. It is stated that in the ordinary case, when the plate receives the optical image at the focus of the telescope, each silver grain requires 10,000 photons for its reduction. This calculation therefore suggests that a gain of 100 times can readily be secured: each grain can now be reduced by 100 photons supplied by the telescope instead of 10,000. This is therefore equivalent to an increase in telescope diameter (as far as intensity goes) of 10 times. That is, as far as light intensity goes, a 20-inch telescope can be made to perform as well as the 200-inch telescope, or that the 200-inch telescope could be made to perform with the light-gathering capacity of a mirror 167 feet in diameter. No one even in their wildest dreams has ever imagined a telescope of normal pattern of this diameter being capable of construction.

The operation of such an instrument poses some tricky problems; for instance the vacuum system will require very powerful vacuum pumps, and in addition the presence of very high voltages will make operation under ordinary observing conditions far from simple. To get all the necessary equipment on to a telescope which must, of course, be capable of movement will also provide a challenge to the designers' ingenuity.

'Feeding' Plants through their Leaves

To what extent can the leaf system of a plant act as an agent of nutrition? It is well enough known that leaves can absorb and exhale moisture. Also, the process of photosynthesis by which leaves take in carbon dioxide from the air has been known considerably longer than most other details of plant nutrition mechanisms. For most of the past 100 years the orthodox picture of the plant's food-obtaining processes has been that the leaves acquire the carbon by photosynthesis while the root system acquires the mineral nutrients from the soil.

In recent years, however, it has been demonstrated that the foliage of plants can be made to play a significant part in mineral nutrition. For example, it has been firmly proved that the trace elements—such as copper, manganese, and zinc—are assimilated by plants when dilute solutions of salts of these elements are sprayed upon the leaves. Indeed, in correcting trace element deficiencies, this method of application is often the most effective, providing quicker and surer relief than applications of solids to the soil. (See "Trace Elements and Plant Growth", DISCOVERY, January 1950). Since these nutrients are required in only minute amounts, this divergence from the orthodox conception of leaf and root functions seemed no more than a minor amendment. Indeed, it was possible to argue that plants suffering from deficiency needed the missing nutrient so badly that the foliage behaved abnormally in assimilating the sprayed solution.

Now, however, it has been shown that one of the major elements—nitrogen—can also be supplied to plants by foliage spraying. The fertiliser that is being used to supply nitrogen by this means is urea. This substance can be synthesised on the industrial scale, and is cheap enough to use as an agricultural fertiliser; applied to the land in the same sort of way as conventional fertilisers, its use in the U.S.A. is steadily increasing.

The more usual and inorganic nitrogenous fertilisers—sulphate of ammonia or the nitrate fertilisers—cannot be applied to foliage in solution, for at any concentration which would give any nourishment they would damage the leaves by 'burning'. This risk must be increased with any inorganic substance owing to their ionisation in dilute solutions; with urea, ionisation would be inappreciable since it is an organic substance. Also, pure urea would contain 46% of nitrogen so that a very high proportion of the dissolved matter would be nutritionally useful: compare sulphate of ammonia, 20·6% nitrogen. These considerations have proved to be correct in trial experiments and practice.

In the past six years, research at Cornell University has shown that nitrogen may be safely supplied to apple trees by spraying their foliage with dilute urea solutions, to give increases in fruit yield up to 30%. One of the first practical attempts to use the spraying method was made in 1947 in the United States with trees grown for shade and decorative purposes in streets; the active roots of such trees lie below the paving stones or asphalt surface, and fertilisers applied in the ordinary way are therefore not a practical proposition. Urea solutions were sprayed on their foliage, and nitrogen deficiencies were corrected. The large U.S. chemical organisation, Du Pont, is now marketing a nitrogenous fertiliser, 'NuGreen', specifically designed for spraying on foliage. 'NuGreen', with a nitrogen content of 44% consists mainly of urea. To make a suitable spray 5 lb. of 'NuGreen' are dissolved in 100 gallons of water. This sounds a fairly dilute solution, but in fact the percentage of nitrogen in it is higher than that in normal soil solution. The nitrogen is said to be absorbed by the leaves within a few hours of spraying. This year it has been reported that excellent responses have been given by rice, citrus fruits, cabbage, cauliflower, lettuce, tomatoes, roses, chrysanthemums, and many other garden flowers.

For horticultural crops this method of application has several virtues. Nitrogen can be supplied just when the plants seem to require it; for crops whose value depends upon 'catching the market' the possibility of 'boosting' growth is attractive. Also, the spray may be combined with many of the common insecticide sprays. In the case of fruit, few orchard soils can provide enough nitrogen for heavy cropping needs; but soil applications can result in an excess of nitrogen at the wrong time, leading to the production of wood rather than fruit. Supplies can be 'timed' much more precisely by spray applications—if necessary two or three times during the fruiting season.

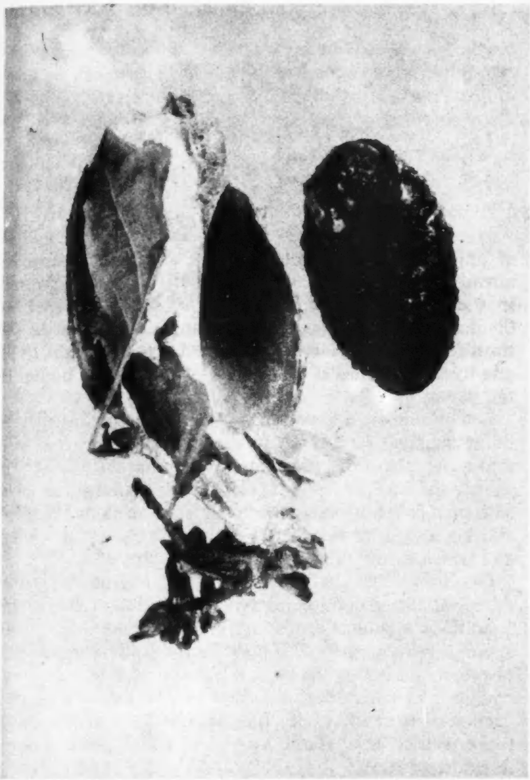
THE INVENTOR OF 'LOGS'

The memory of mathematicians has rarely been perpetuated in the tomes of biographers, though the tale of the great calculators is vividly coloured at times. One need but turn to George Bidder, taken as a boy around the country as a 'calculating phenomenon'; to the farm labourers Buxton and Mole, the first who could in a twinkling double a farthing 139 times and give the answer in pounds to thirty-nine figures, the second with his 'visualising' numbers and his work in algebra. Or turn to De Condorcet with his famed *Calculus*, a great work which could not save him from the Revolution when, disguised as a carpenter, he betrayed his aristocratic mien by asking for an omelette with too many eggs for a poor man. And now to Napier of Murchiston (1550–1617), inventor of logarithms.

Though one or two soldiers and an admiral or two have brought lustre to the name of Napier, the laird of Murchiston who gave twenty years to mathematics deserves more commemoration. Logarithms, as we know them today, certainly owe something to others than Napier. There was Joost Bürgi, for example, born two years after Napier. Also Henry Briggs, that brilliant Cambridge man whose Greek epitaph maintains that "his soul still astronomises while his body geometrises". Yet logarithms came to the calculator's aid all because of Napier's touch of genius after he had retired to his Scottish castle on the banks of the Endrick, where occasionally he had to ask the miller in the lint mill opposite to stop his clanking lest it stopped his own train of ideas.

John Napier began very much like Emil Fischer began who was "such a miserable failure" in the lumber trade that his father decided he "may as well send him to college". He spent a short spell at St. Salvator's College in St. Andrews, and then studied abroad. At twenty-two he returned to Scotland, where his social position was such that he could devote his life to literary and mathematical studies. He proceeded to spend some twenty years in efforts to systematise and develop algebra and arithmetic, in musing on 'imaginary roots', and then turning to 'artificial numbers', as he first called his logarithms.

Until Napier's inspiration changed mathematical history it seemed an axiom that multiplication could not be simplified, since it was plainly fundamental. Yet long before he published, in 1614, his *Mirifici logarithmorum cannoni descripti*, he had sent Tycho Brahe a summary of his scheme. His invention by itself did not give the world those everyday logarithms used by a host of mathematical students. For Napier's tables gave 'logs' of sines, cosines, and other functions of angles; and they had plus and minus values together with other drawbacks. But John Speidler soon modified them to positive values. Then Henry Briggs, "as soon as the season of the year" permitted a visit to cold Edinburgh, "as soon as the vacation of his public duties of instruction" at Gresham College allowed it, was off to the northern city, there to "linger for a whole month", to be received with open arms by Napier. The base of 10 was introduced in place of Napier's 'radix', and Briggs calculated the logarithms to that base of 30,000 natural numbers before he died. So were born the log tables now familiar to so many millions of people. M. SCHOFIELD.



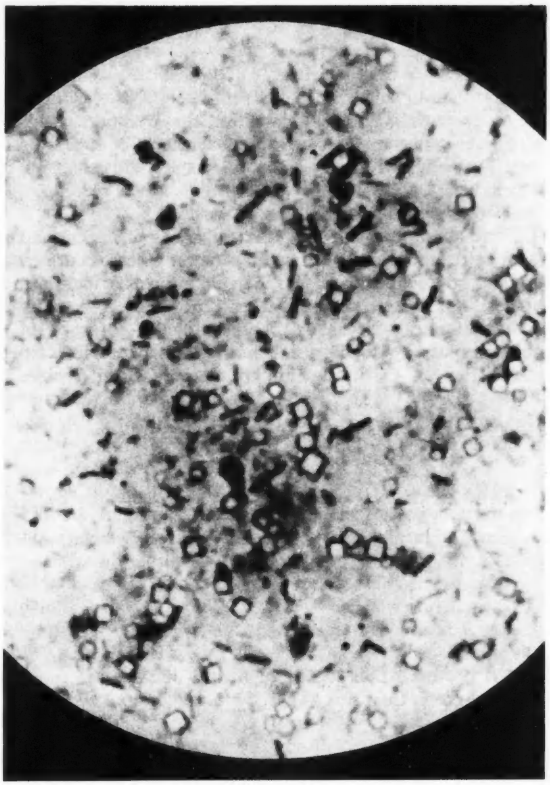


FIG. 1 (*left*).—Cocoon of the larva of a giant tropical silk moth, cut open to show the dead and blackened larva which was full of polyhedral bodies. (*Photo*: *J. H. Hitchborn*.) FIG. 2 (*right*).—A blood smear made from a caterpillar of the scarlet tiger moth which was infected with a polyhedral virus disease. Note the large numbers of polyhedral bodies which in this case are rectangular. The rod-shaped bodies are bacteria. Photographed on the ordinary microscope at a magnification of $\times$ 1200. (*Photo*: *Roy Markham*.)

Virus Diseases of Insects

KENNETH M. SMITH, Ph.D., F.R.S.

Director of the Plant Virus Research Unit, Molteno Institute, Cambridge

VIRUSES are extremely minute disease agents which attack all kinds of living organisms from bacteria to man. They are mostly beyond the limit of resolution with the optical microscope and some of them are so small as to be of molecular size.

Now insects are closely concerned with viruses and this association may be of three types. First, insects carry viruses which are deadly to other organisms, but they are not, themselves, adversely affected by them. These *insect vectors*, as they are called, are very varied and so are the viruses they transmit. Mosquitoes carry yellow fever to man and encephalomyelitis to horses; aphides transmit the leaf-roll virus to potatoes, and leaf-hoppers in the U.S.A. spread the viruses of sugar beet and asters, whilst mealy bugs are responsible for the distribution of the swollen-shoot virus which is causing such devastation to the cocoa industry on the west coast of Africa.

There is no evidence that these insect vectors are in any way affected by the viruses they carry. Mosquitoes which are infected with the yellow fever virus seem to live just as long as non-infective mosquitoes of the same species, and similarly with the insect vectors of plant viruses. Now of the second type of insect-virus association, there seems to be only one example. Here we are again dealing with an insect vector of a virus, but in this case the insect itself is fated to die more surely than the victim it infects. The body louse which transmits typhus fever invariably succumbs itself, about eight days after it first picks up the infection.

In our third type of insect-virus association, the insect itself is attacked by viruses and it is this type of virus disease with which we are concerned in this article.

Of all the different types of virus diseases, those affecting insects have been the most neglected and only recently have any serious investigations been commenced.

Virus diseases of insects are no new thing, although we have no references going so far back in history as we have, for instance, to smallpox and the mosaic disease of tulips. Nevertheless it is interesting to find that Pasteur, in his classic study of the silkworm disease 'flacherie' in 1867, was actually dealing with a virus disease and that the bacterium which he thought was the cause was only a secondary invader, the primary agent being a virus.

There are various types of virus diseases of insects and most of them are characterised by the presence of curious bodies in the cells of the host which are known as 'inclusion bodies'. Of these diseases the best known are the 'polyhedral diseases', so called because of the presence of millions of many-sided crystals in the body of the infected insect (Fig. 2). Curiously enough, the polyhedral diseases affect only the larval stages, and particularly the caterpillars, of butterflies and moths. The silkworm is very susceptible to a polyhedral disease, to which the name *jaundice* is given because of the characteristic yellow colour of the affected caterpillars. The larvae of the well-known nun-moth, a pest of shade trees on the Continent, are also frequently attacked by a polyhedral disease. The Germans gave it the name *Wipfelkrankheit*, or tree-top disease, because infected caterpillars have the habit of crawling to the top-most branches where they die but remain hanging head downwards still held in place by the grip of their abdominal sucker feet.

It is probable that these polyhedral diseases are much more common than was at first supposed. At all events as soon as a serious attempt is made to find them, there seems to be no difficulty in discovering many apparently new viruses. For example, no fewer than four distinct polyhedral viruses have been found recently, each one of which attacks a separate species of the caterpillars of the well-known tiger moths, beloved of collectors; the scarlet tiger, the Jersey tiger and so on.

The virus disease which attacks the scarlet tiger differs from the other three by the fact that the polyhedral bodies are rectangular and this sharply differentiates them from those of the more usual shape (Fig. 2).

In addition to the tiger moth larvae, apparently undescribed viruses have been found attacking the larvae of the currant moth—that rather brightly coloured caterpillar which is sometimes a pest of currant and gooseberry bushes—and also the larvae of three species of the giant tropical silk moths.

Polyhedral diseases are extremely infectious and in doing experimental work with caterpillars, one of the chief difficulties is to keep out unwanted viruses. The polyhedral bodies themselves are very resistant and retain their infective power for long periods, sometimes for years. (The relationship between the virus and the polyhedral bodies will be explained later when we discuss the viruses themselves.) The disease is communicated mainly by the mouth and the caterpillars become infected after eating foliage contaminated by other infected larvae. Once the disease has commenced it seems to be invariably fatal and the final breakdown of the body contents in the last stage is extremely rapid. If the blood cells of a caterpillar in the early stages of infection are examined under high magnification, the cell nuclei will be seen to be tightly packed with polyhedral bodies (Figs. 3 and 4). After a time the swollen nuclei burst and the cells themselves become filled with polyhedra. Those in turn are ruptured and the body of the caterpillar finally becomes a mere sac filled with millions of these curious and highly characteristic crystals.

Symptoms of Disease

The appearance of virus-infected caterpillars varies according to the kind of caterpillar and the kind of virus. As a rule, the first sign of infection is sluggishness and loss of appetite, then the colour of the skin may change as already mentioned in the case of the jaundiced silkworm. In the larvae of the common clothes moth, affected individuals take on a milky appearance in contrast to the translucent healthy larva. This milkiness is thought to be due to the presence of thousands of polyhedral bodies in the tissues.

Sometimes when a caterpillar is infected late in its larval life it manages to spin up its cocoon and start to change into a pupa before it succumbs to the disease. In Fig. 1 is shown the cocoon spun by an infected caterpillar of a tropical silk moth. It has been cut open to show the dead and blackened larva which was full of polyhedral bodies, and which died before it could form a chrysalis.

One important characteristic of insect virus diseases is the spontaneous development of a polyhedral disease under conditions where the possibility of external infection is apparently ruled out. The most likely explanation of this phenomenon is that the virus is already present in a latent condition in some caterpillars and may be passed from one generation to another until, finally, under certain conditions the virus is stimulated into activity and the disease appears in epidemic form.

So far we have touched briefly upon the virus diseases of insects and the curious polyhedral bodies associated with some of these diseases. But we have not yet mentioned the viruses themselves, the primary cause of all the trouble. It has been shown by Bergold who has done much of the pioneer work on the virus diseases of insects that the polyhedral bodies are not the viruses themselves but contain the virus particles within them. He showed that if a polyhedral body was dissolved in a weak alkali and then photographed on the electron microscope during its disintegration, the virus particles which are actually rod-shaped, could be seen in a kind of socket or chamber in the polyhedral body.

We have said that most viruses are beyond the resolving power of the optical microscope and this is true of the plant viruses, but some at least of the insect viruses are large enough to be seen with the ordinary microscope by dark ground illumination, as bright particles moving rapidly against the dark background. If a suspension of polyhedra in weak alkali is observed under dark ground illumination at a magnification of about $\times 1500$ an interesting phenomenon can be seen. As the polyhedral body dissolves, the virus particles imprisoned in the crystal are liberated and they can be watched darting hither and thither inside the membrane which enclosed the now disintegrated polyhedral body. As the particles rebound from side to side of the membrane occasional individuals pass through a break in the membrane and disappear outside the field of view. It is not suggested, of course, that the virus particles have any power of progression of their own: this type of movement is called 'Brownian

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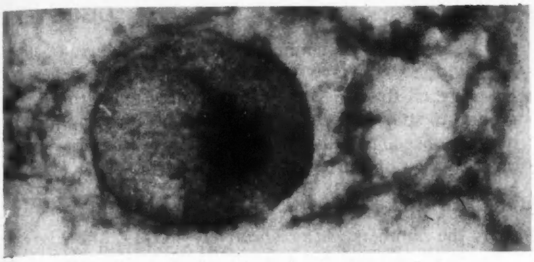


FIG. 3.—A section through the larva of the currant moth, infected with a polyhedral virus disease. The round objects are the cell nuclei and the honey-comb structure is due to the presence of thousands of polyhedral bodies. × 1500. (*Photo*: *Roy Markham*.)

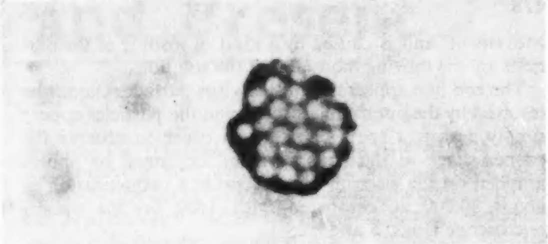
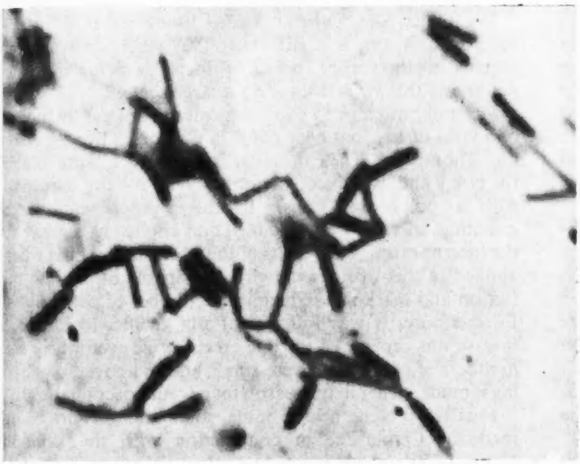


FIG. 4.—A blood smear from a larva of the common clothes moth infected with polyhedral disease. The greatly enlarged nucleus of one of the blood cells can be seen, packed with polyhedral bodies. × 1500. (*Photo*: *Roy Markham*.)



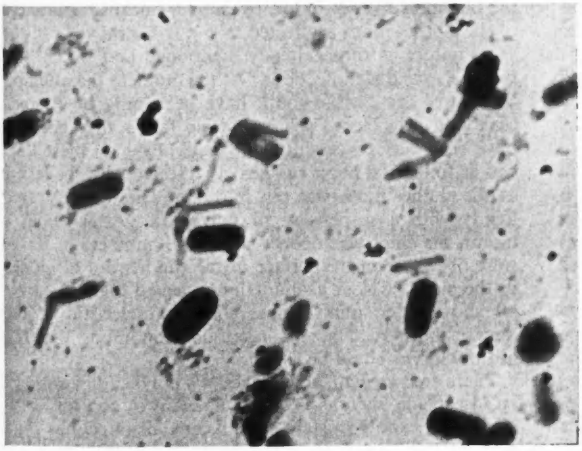


FIG. 5 (*top*).—Photograph taken on the electron microscope, of the virus particles themselves. Note that they are rod-shaped and occur singly and in bundles. This is the 'jaundice' disease of the silk-worm. × 30,000. (*Courtesy*: *G. Bergold*.)

FIG. 6.—Photograph taken on the electron microscope, of the polyhedral virus attacking the larva of the gipsy moth. Note the bundles of virus rods and how they can be seen separating into single rods. × 30,000. (*Courtesy*: *G. Bergold*.)

FIG. 7.—A series of photographs, taken on the electron microscope by G. Bergold, of what appear to be development stages of the polyhedral virus from the gipsy moth caterpillar. The first four pictures show a spherical 'germ', in the next four are stages of straightening and thinning of the 'germ'. The next two pictures show the rods leaving their enclosing membrane and apparently splitting into four single rods. The last picture shows various of these 'developmental' forms. × 43,000. (*Courtesy*: *G. Bergold*.)

Movement' and is caused by a kind of jostling of the particles by the moving molecules of the solution.

The rod-like appearance of the virus particles cannot be resolved by the optical microscope and the particles appear simply as bright spots of light. In order to observe the proper shape of the virus particles they must be photographed on the electron microscope at a magnification of about 30,000 as compared with 1500 on the optical microscope (Figs. 5 and 6).

By means of the electron microscope much information has been obtained on the shape and appearance of the actual particles of insect viruses; in this work Bergold has played a leading part and some of his electron micrographs of the viruses are reproduced in this article.

Photographs taken on the electron microscope of the comparatively large virus of influenza show the particles to be mainly of a spherical nature, but there also occur, from time to time, much larger, elongated structures. It has been suggested that these different particles may conceivably be stages in some kind of a life-cycle. Bergold considers that possibly a similar state of affairs exists with the insect viruses, which are also comparatively large, since he has been able to photograph different kinds of virus particles which may be part of a development cycle.

Bergold postulates a rather complicated system of multiplication somewhat on the following lines. The virus appears first as a minute spherical body or 'germ' which increases in size and develops into an elongated, curved body, surrounded by a membrane. Later the virus particle straightens out, ruptures the membrane and appears as the rod-shaped particle characteristic of most insect viruses. It is thought that this rod-shaped particle contains several smaller sub-units each of which develops into a rod. Some of these different forms are shown in Fig. 7.

If this theory of a developmental cycle is confirmed by further investigation it will be most important and interesting because it suggests that these rather large insect viruses may be organisms of a nature hitherto unknown. At present there is no evidence of anything of a similar kind with regard to the much smaller plant viruses.

We know that natural outbreaks of polyhedral diseases occur from time to time in the great infestations of gipsy moth and nun moth caterpillars in forests in Germany and elsewhere. When this happens, the infestation dies down and it may be several years before the numbers of caterpillars build up again. When one of these virus epidemics is in progress, the number of polyhedral bodies produced is so great that they form a fine white dust on the surrounding trees. It seems logical therefore, that by the large-scale production and dissemination of caterpillar viruses some degree of control of outbreaks of injurious insects might be achieved. This possibility is being investigated at the present time in several countries. In Quebec much defoliation of the spruce trees has been caused by the larva of a sawfly, which belongs to the Hymenoptera, the order containing ants, bees, and wasps. The outbreak of larvae commenced in 1930 and reached its peak several years later, about 1938. After that the outbreak declined until in 1940 it practically disappeared. Balch and Bird, two Canadian workers, consider that this decline coincided with the development of a polyhedral disease among the sawfly larvae, and they offer some interesting evidence in support of this conclusion. Their method of recording the effect of the disease was to count the number of larvae which reached the sixth-stage without being infected. When the larvae reach this stage they stop feeding and drop to the ground to spin their cocoons. Balch and Bird counted the number of such healthy larvae which dropped to the ground on a given plot during the years 1939–41. One example is as follows: in 1938 the total number of healthy larvae dropping from the trees was 1389; in the following three years the numbers were respectively 465, 19, and 2 larvae. It has been calculated that the percentage mortality on the plot ranged from 94·8% one year to 99·7% during the next three years.

By introducing extracts of dried diseased larvae into Newfoundland, the disease was established there, where previously it had been unknown.

In Canada, also, a virus has been discovered affecting the spruce budworm, a small caterpillar which causes great damage to the spruce forests. Efforts are being made to propagate this virus disease on a large scale.

A similar attempt to control a caterpillar pest by means of a virus disease has been made in California by Steinhaus and Thompson. The caterpillar in question attacks alfalfa (lucerne) and is subject periodically to natural infection with a polyhedral virus. In these experiments large quantities of virus were obtained and applied as a spray to the lucerne crop. The results of the work suggest that when applied in this manner the virus is capable of causing infection and markedly reducing the number of caterpillars. Furthermore, it was found that this artificially induced disease was capable of starting an epidemic even where the numbers of caterpillars were small, and moreover, of starting it much earlier in the season than would occur naturally.

Finally, to come nearer home, some attempts are being made at Cambridge in conjunction with the London Natural History Museum, to control that familiar insect, the common clothes moth, by similar means. The larva of the clothes moth is affected by a polyhedral virus of the same nature as those already mentioned and which, like them, is extremely infectious. At the moment the attempts to control the clothes moth have been only on a small scale and in enclosed spaces but, so far as they go, they have been very successful. One experiment on these lines was as follows: a horse rug heavily infested with the larvae of the clothes moth was put in a large chest and sprayed lightly with a suspension of polyhedra. After about a month the chest was opened and large numbers of larvae were observed on the surface of the rug instead of hidden in the cloth. Closer examination revealed that the larvae all showed the milky appearance characteristic of the disease and were in fact in a moribund condition. Very few healthy larvae could be found.

There are two main advantages of a polyhedral virus over an insecticide, such as DDT, as a means of control. First it is much more persistent since it remains infectious for a year and probably longer, and secondly it is self-propagating in the sense that it is passed from larva to larva, multiplying all the time.

We do not know yet how successful the polyhedral virus will be in the control of the clothes moth on a large scale where a confined space, such as a chest or closet, is not concerned. The main difficulty will probably be the preparation of sufficient virus since the quantities so far obtained have been comparatively small.

Quinine Past and Present

TREVOR I. WILLIAMS, B.A., B.Sc., D.Phil.

THE cinchona tree can claim a high place among those few plants which have had a decisive influence on the history of the world. Quinine, the active principle of the bark of the cinchona tree, has the double distinction of being not merely the first discovered specific against an infection of the human body but also the conqueror of a disease which takes as heavy a toll as any of human life and happiness. Estimates of the number of people attacked by malaria every year range from 300 to 800 million; of these not less than 3 million die. For some three centuries quinine has played an essential role in the development by the white races of the many tropical regions—such as many parts of Africa and India—in which malaria is endemic. Without it the penetration of these countries would have been much slower than in fact proved the case, and the rewards far less. We should have been deprived of the abundance of tropical products which in normal times make life simpler and more pleasant. The establishment of rubber plantations, for example, which provide one of the most vital of all products needed for modern road transport, would have been very much more difficult.

Although we know within a few years the date of the introduction of quinine into Europe—an event which occurred a little more than three centuries ago—the circumstances of its discovery are far from certain. Although there is a school of thought which claims that the natives of South America were unaware of the virtues of the cinchona tree for the treatment of malarial fevers, there is a good deal of evidence that, in fact, it was from the natives that the Spaniards first gained their knowledge of the drug which they exploited so rapidly and so successfully.

There is a tradition that the Countess of Chinchón, wife of the Spanish Viceroy, played a leading part in the introduction of quinine into Europe. Linnæus clearly accepted this story, for it was the reason for his giving the tree the generic name *Cinchona*, a misspelling of the countess's name which has been perpetuated in botanical literature ever since, despite repeated attempts to correct it. However, this attractive legend is no longer generally accepted, although there are still certain important details which remain obscure, so that it cannot be said to be finally discredited.

Although this is not the place to discuss in detail the truth or otherwise of the legend, no account of the history of quinine would be complete without some reference to it.* The story is that the first European to be treated with quinine was a Jesuit missionary, who fell ill with fever at Malacotas, a settlement some miles south of Loxa. On his return there he spread the story of the remarkable curative properties of the native drug. In 1630 the Corregidor of Loxa himself fell ill with malaria and was restored to health with the aid of the drug which, according to a manuscript reputed to be lodged in the library of a convent at Loxa, was in general use among Europeans in the district at that time. Subsequently, in 1638, the Countess of Chinchón, wife of the Viceroy, contracted an intermittent fever. Remembering his own cure, the Corregidor sent her a supply of powdered bark by the hand of his own physician, Dr. Juan de Vega. Again the drug was successful, and the tradition is that the Countess was so impressed with the drug that she introduced it as widely as possible to her fellow-countrymen, and thus to the world at large.

* Readers who want further details should consult J. Taramillo-Arango, "A Critical Review of the Basic Facts in the History of Cinchona", *Journal of the Linnean Society*, 1949, Vol. 53.

The main evidence against this pleasing story is that it is not mentioned in contemporary writing—especially in the Count of Chinchón's minutely kept private diary which is still preserved—though it was widely diffused as early as 1663. It is not impossible, however, that, in view of the violent prejudices common in medical affairs at that time, the Count himself had no use for quinine and preferred to ignore his wife's experiments with it. It is certain that as early as 1633—eight years before the death of the Countess—the drug was "producing miraculous results in Lima".

It is, perhaps, academic to attempt now to assign the credit for introducing quinine into Europe; the excuse for the many attempts made is that although rarely recognised as such, it was, for such reasons as those given above, an event of outstanding importance in world history. It is, however, certain that, apart from the question of the individual originally concerned, the chief disseminators of knowledge of quinine were the Jesuits, a circumstance which earned the drug the name 'Pulvis Jesuiticum'.

In Britain the early history of quinine is very closely interweaved with that of the adventurer Robert Talbor, who—denouncing Pulvis Jesuiticum as a dangerous drug—hawked his own specific for the cure of fevers. His success in treating Charles II secured royal patronage for him and a knighthood. Subsequently he was called to France to treat the Dauphin, which he did very successfully. Thereafter Louis XIV urged Talbor to sell the secret of his remedy. This he eventually did, with the proviso that it should not be disclosed until after his death. When Talbor died in 1681 he was famous throughout Europe; his remedy—essentially an infusion of cinchona bark in wine, together with syrup of poppy and other ingredients—was published immediately and thereafter the use of quinine was firmly established.

The drug, under the name Cortex Peruanus, first appeared in the London Pharmacopeia in 1677, and within half a century was universally used by the medical profession. James Alleyne, for example, in his New English Dispensatory of 1733, gives a number of prescriptions which include quinine. Thus an electuary of Peruvian bark and syrup of red roses is "almost infallible in all intermittents and is to be given the quantity of a large nutmeg every three or four hours, betwixt the fits".

The use of quinine became, indeed, so popular that the only natural source of supply—the forests of South America—became almost exhausted by the early nineteenth century, with the consequence that the price of powdered bark rose to as much as £5 per ounce. In fact, the trade became so profitable that unscrupulous merchants sold instead other astringent powders, made bitter by addition of aloes. In

recent times a similar black market in pseudo-penicillin flourished on the Continent.

At the cost of his life—for strict measures were taken to maintain the monopoly—an Englishman, Charles Ledger, smuggled some seeds of the cinchona tree out of South America to his brother in London. Half was offered to the British Government, which at first refused them, though they were eventually sent to a planter in Ceylon. The other half were purchased by the Dutch Government for only £33. In 1854 the Dutch shipped several hundred young trees to Java where, since they proved well suited to the soil and climate, they flourished, trees commonly yielding two or three times as much of the drug as they did in the wild state in South America. Quite soon a large industry was established and by 1939 Java was supplying the greater part of the world's quinine, exporting 15,000,000 pounds of bark annually.

Java was not, however, left entirely without competitors. In 1859 trees were introduced into Ceylon and India, and though the Ceylon experiment failed, a number of Indian plantations were successful. Meanwhile the South American traders realised with dismay that their monopoly of two centuries had vanished and recognised that to retrieve their fortunes their only hope was to establish their own plantations. This was done, with considerable success, in Bolivia, Columbia, and Peru.

The first illustration of the cinchona tree, from *Historiarum Anatomicarum & Medicarum Rariorum, Centuria V* by Thomas Bartholinus, published in 1661.

The remarkable properties of cinchona bark attracted the attention of chemists at a very early date. As early as 1792 Fourcroy isolated a crude alkaloid which he named quina. A few years later a Spaniard, Gomez, obtained a crystalline product which he called cinchonino. In 1820 Caventou and Pelletier showed that the bark contained two distinct alkaloids—quinine and cinchonine. Since that time exhaustive research has shown that the bark contains thirty different alkaloids, and doubtless others, present only in traces, still await recognition. However, only four of these —quinine, quinidine, cinchonine, and cinchonidine—contribute significantly to the antimalarial properties of the drug, and of these quinine itself is much the most important.

These four antimalarial drugs fall into two pairs, one member of each having a curious relationship to the other. The molecule of quinine and the molecule of quinidine each consist of the same number of atoms of carbon, hydrogen and nitrogen arranged in the same sequence, and at first sight it seems that there is not the slightest difference between them. Closer examination shows, however, that there is a subtle difference; one molecule is related to the other very much as a left-hand glove is related to the right-hand member of the same pair or as an object is to its image in a mirror. Although each follows the same pattern, it is not possible to superimpose one molecule exactly on the other. Chemists call this phenomenon, which is quite common, stereoisomerism.

This seemingly trifling difference in structure is reflected in quite large differences in the action of the drugs. Thus quinidine is considerably less effective than quinine in treating malaria. It is, however, sometimes useful for treating patients who, through personal idiosyncrasy, react unfavourably to quinine itself. A further use for quinidine is in treating the cardiac disorder known as cardiac fibrillation.

Until the nineteenth century, quinine was used exclusively in the form of the crude bark, which contains from 2 to 5% of the pure alkaloid. Today, however, the pure drug is almost exclusively used. The usual method of extraction is to mix the bark into a paste with lime and to dry this thoroughly. The quinine and other alkaloids are then extracted with an organic solvent, such as amyl alcohol, from which they are in turn removed by shaking with dilute hydrochloric acid. When the acid solution is made alkaline the alkaloids are precipitated and can be filtered off. The quinine is then separated by careful crystallisation of the quinine salt from water. The alkaloid itself is almost insoluble so that in medicine it is commonly used in the form of a salt, generally the sulphate formed by combination with sulphuric acid.

In view of the world-wide demand for quinine it is scarcely surprising that attempts to synthesise it began soon after serious interest was taken in organic chemistry. Perhaps the most interesting of these abortive attempts was that of W. H. Perkin. At the age of eighteen he conceived the idea of making quinine from a substance called allyl toluidine, which he had isolated from coal tar. The experiment failed—it was in fact bound to do so—and instead of quinine he obtained mauve, the first synthetic dye-stuff. Thus was the modern dye-stuffs' industry born. It is, however, only very recently that success has been recorded, though the precise arrangement of the atoms within the quinine molecule has been known for over forty years. The successful chemists were Americans, R. B. Woodward and W. E. Doering. Their original method of synthesis had, however, no commercial possibilities whatever, and there is no indication that subsequent research has brought us any nearer the possibility of commercially producing synthetic quinine. For the making of quinine the world is still as dependent on the cinchona tree as it was three centuries ago.

Nevertheless, quinine is being very seriously challenged from quite a different direction—by synthetic antimalarial drugs whose structure is totally different. To understand the significance of these it is necessary to refer briefly to the complicated life-cycle of the malaria parasite.

The malaria parasites—of which there is a variety of strains causing somewhat different symptoms—are introduced into the human victim by the bite of the female *anopheles* mosquito, which carries them inside her salivary

gland. After a few days they make their way into the red blood corpuscles within which, after a variable resting period, they divide into smaller forms called merozoites. These burst out of the original corpuscle—destroying it—and attacking others, within which the process occurs again. The bouts of fever coincide with these successive invasions of the blood-stream by parasites bursting out from the corpuscles. After a few such cycles of asexual multiplication, a different form of reproduction occurs. Some of the parasites within the corpuscles become converted into male germ cells or gametocytes, others into female gametocytes. These, too, eventually burst out into the blood-stream but thereafter no further change occurs within the human victim. Only within the body of the mosquito, into which they may be drawn when it sucks blood, do the germ cells recombine. After the union the new individuals eventually make their way to the mosquito's salivary gland and are ready once again to attack another human being.

Quinine suffers from the disadvantages of being mildly toxic—the symptoms of cinchonism including visual disturbances, deafness, and ringing in the ears—and in having a very bitter taste. Rather more serious is its limited action against the malaria parasite, which it attacks primarily only during the time it is free in the blood; that is to say, during the bouts of fever. Parasites newly injected by the bite of a mosquito are not killed, though they may develop abnormally, with the result that they become quiescent. These quiescent forms may, however, develop years later after the victim has left the malarial region and discontinued the use of the drug. Nor does quinine destroy the gametocytes, so that even a person taking the drug regularly can be a potential source of infection for others. The main use of the drug is, therefore, as a prophylactic, suppressing the bouts of fever which normally follow infection. It will not prevent either infection or the transmission of infection, nor will it remove the danger of relapse. As a prophylactic it is, however, very successful. On practical grounds one of its biggest drawbacks is its relatively high cost.

These disadvantages led to a close study of synthetic antimalarial drugs, notably in Germany. The first of these to meet with any great success was plasmoquine, discovered in the Bayer Laboratories in 1924. Although very toxic, it was so much more active against the malaria parasite that the therapeutic dose was in fact less poisonous than was the case with quinine, from which, however, it differed in its action. It destroyed the gametocytes of one of the most dangerous forms of malaria as well as attacking the asexual forms actually responsible for the bouts of fever. It, therefore, had possibilities for preventing relapses and for this reason was often used in combination with quinine.

Further research led to the discovery, in 1933, of atebrin, known in England as mepacrine. This attacks the malaria parasite in substantially the same forms as quinine does, but it is not completely non-toxic and has the disadvantages of causing a deep yellow coloration of the skin and of being difficult to produce.

The circumstances of the last war led to the widespread replacement of quinine by mepacrine. The Japanese invasion of Java, the world's largest producer of quinine, coincided with the need to maintain very large Allied armies in regions where malaria is prevalent. Despite elaborate German attempts to maintain the secret of manufacturing atebrin, the Allied chemical industry speedily mastered the intricacies of its production and produced it in very large quantities throughout the war.

Although mepacrine proved satisfactory in the military campaigns and as a general substitute for quinine, search for an improved antimalarial was rigorously pursued in both Britain and the United States. The requirements are a drug which is not toxic, causes no skin coloration, is active against all phases of the parasite, and is capable of being produced cheaply in quantities large enough to make possible a strong campaign against malaria even among the poor and primitive peoples of Asia and Africa who are numerically the heaviest sufferers.

The recently introduced British drug paludrine—it was discovered in 1943—seems to come nearest to meeting these requirements. This possesses definite advantages over mepacrine in being less toxic, effective against the parasite through a greater part of its life-cycle, cheaper to produce, and causing no discoloration of the skin. The results of very extensive clinical trials have been excellent.

It is as yet too early to say how far paludrine and mepacrine will supersede quinine now that the latter is freely available again, but there is no doubt that the synthetic antimalarials will prove strong competitors. There seems, indeed, little doubt that in practice paludrine is therapeutically superior to quinine, but against this must be set the very firmly established reputation of quinine and the fact that the superiority of the synthetic antimalarials is of degree rather than of kind. Such a reputation will not rapidly be lost.

Quinine has the further advantage in the competitive period undoubtedly lying ahead that its uses are not limited to the treatment of malaria. It is, for example, a valuable antipyretic or temperature-reducing drug. Because of its bitter taste, which whets the appetite, and its promotion of digestion, it is often prescribed as a tonic. Ordinary tonic water—widely sold as an apéritif—contains quinine.

Quinine itself and, more particularly, certain of its derivations, have some antiseptic properties and preparations containing them are being developed commercially. It is possible that in the event of a decline in the use of quinine as an antimalarial these and other uses for the drug can be developed.

Finally, it must be recognised that quinine, paludrine, and all other antimalarial drugs have to be considered in relationship to other substances which are attacking malaria in quite a different way. These substances are the new and highly potent insecticides, such as DDT and Gammexane, which are being widely used in campaigns to destroy insect pests, including those which, like the *anopheles* mosquito, are carriers of disease. The female anopheles mosquito is an absolutely essential link in the parasite's life-cycle. If the mosquito could be completely eradicated the malaria parasite could no longer infect new victims. Such a total eradication will not be effected for an extremely long time—if ever—but already antimosquito campaigns, using the new insecticides, have had spectacular success in many countries in reducing the incidence of malaria.

In the immediate future we can expect to see more and more 'technical assistance programmes' coming into operation, as the technical knowledge of the more advanced countries is brought to bear on the problems involved in developing the backward countries of the world. International organisations such as Unesco, F.A.O. and the World Health Organisation have great responsibilities in this direction, but contributions to the solution of these problems must also be made by individual nations. President Truman recognised the need for the U.S.A. to play its part; hence his 'Fourth Point' programme. In this article, Raymond Blackburn, a leading figure in Britain's Parliamentary and Scientific Committee, which is studying how Britain and America can collaborate in this connexion, discusses the 'Fourth Point' scheme, and the importance of 'technical assistance' within Britain's sphere of influence.

Technical Assistance Programmes

RAYMOND BLACKBURN, M.P.

THE problem of the under-developed areas of the world—almost the whole of Asia, Africa and South America—is, from a long-term point of view, the gravest of all the problems which we have to face. Tens of millions in India and Pakistan live on the borderline of starvation; yet the population increases by 5,000,000 per year. Moreover, starvation generates misery; misery generates hate; hate generates cruelty and unrest which reduce productions and lead to more starvation. This is an even more sinister chain reaction than any which we have discovered in nuclear physics. Indeed, it is the atom bomb of the Communists and more effective than that which burst over Hiroshima. It has already played a great part in securing the greatest conquest of this century—the Communist victory in China.

President Truman's Fourth Point is the attempted answer to the double danger of starvation in, and Communist infiltration in, the backward areas of the world. The policy was announced by the President as long ago as January 1949, and was designed to achieve a more extensive employment of American technological aid and capital for the benefit of backward areas in the world in co-operation with other nations. There has been no spectacular response to this proposal, such as was given first by Mr. Bevin and then by the Foreign Secretaries of Western Europe immediately after the famous Marshall speech at Harvard. Indeed, unofficially, the scheme was regarded as being more of an idealistic proposal with propaganda value attached than a sober and realistic inauguration of a new era in relations between America and the under-developed regions of the world.

Nevertheless, very considerable study has now been given to the implementation by phases of President Truman's Fourth Point. The Administration has asked Congress for an appropriation of 45,000,000 dollars for the next fiscal year. Congress has reduced the amount to 25,000,000 dollars, but the Senate will be asked to authorise the full 45,000,000 dollars. If the Senate agrees, a joint Committee of Congress and Senate will negotiate an agreed amount. It is expected that the first work under the Point Four programme will commence on July 1, 1950, the beginning of the next American fiscal year. Agriculture, health and education have the highest priority. Some 300 experts will be made available for work mainly in tropical countries, but only on the basis of the greatest possible self-help by those countries. The programme is being launched largely in conjunction with plans prepared by the appropriate departments of the United Nations Organisation—notably the Food and Agricultural Organisation and the World Health Organisation (who will make use of 175 out of the 300 experts already earmarked).

Under the Act for International Development, the President will be specifically authorised to expand the work of American technical co-operation, so far largely confined to Latin America, and spread it to other under-developed areas where the right conditions prevail. The President, if convinced that U.N.O. can in any respect do the job better, may contribute both funds and personnel directly to U.N.O.

Mr. Dean Acheson has emphasised that the programme "is not and never will be a big-money enterprise". Although he wants to encourage private investment in the under-developed areas and is trying to produce certain guarantees against loss of capital through expropriation or inability to convert local currencies, he is not proposing any direct large-scale Government investment. The American Government will not build large mills, mines or factories. At most, it appears, they will provide free the services of skilled people. Moreover, even where the Government is willing to guarantee private American investors against local risks, the investors will have to pay for the insurance effected.

It might well seem that the Fourth Point has been whittled down to a very insignificant point. But both Secretary Acheson and Under-Secretary McGhee maintain that very great advances are possible merely by the provision of technical co-operation. Indeed they assert that large-scale development schemes are, in general, not suitable for the under-developed areas because of their "lack of technical skill, administrative talent, local capital and other factors". They agree with the report of the United Nations Economic Survey Mission to the Near East headed by Mr. Gordon Clapp, Chairman of the Tennessee Valley Authority. He recommended that instead of trying to start a T.V.A. for the Tigris and Euphrates or the Jordan "there be undertaken modest demonstration projects which could give the countries concerned experience in the balanced and unified development of a small area in all its aspects through proper use of water resources, afforestation, terracing, road building and related projects".

'Modest demonstration projects' seem to be the main objective of this new organisation. The Americans wish to build upon experiments which have already proved successful. Examples come for the most part from South

America. The Institute of Inter-American Affairs, in collaboration with the Brazilian Government, has largely cleared the Amazon Valley of typhoid fever and dysentery by making the water supplies safe. There is an enormous need for sanitation engineers throughout the world. Again, in El Salvador, American agricultural experts have helped local farmers by recommending how they can improve their crop yields by the use of fertilisers and other means; one of these farmers who took their advice tripled the yield of maize by applying sodium nitrate. The spread of the technique of hybrid-corn production and the use of better seeds and fertilisers is obviously essential to that increase in agricultural productivity which can alone save the backward areas from starvation.

There are obvious and enormous advantages which the American export industry can derive from large numbers of American experts and technicians being distributed all over the undeveloped areas of the world as advisers to local governments. This fact does not often emerge from the statements and reports which have been published. The American Government seems anxious to dissociate itself, not so much from the charge of attempting to advance their own business interests under the mark of philanthropy, but from the stigma of imperialism. Speaking of the countries which have recently attained independence, Mr. McGhee said, "Although we are not a colonial power and although neither our Government nor American business interests has an imperialist mentality, these countries unfortunately tend to associate us with this mentality because of our European antecedents and our close economic and political alignment with the European powers."

Again, Mr. McGhee is anxious lest native peoples should resent the "capitalist system which in many cases represented to them an instrument of oppression". So while favouring free enterprise capitalism "generally whenever there exist industrious people bent on developing their economic potentialities", Mr. McGhee does not regard it as right to make "American assistance to under-developed countries contingent upon acceptance of our special branch of democracy". Free enterprise is to be encouraged wherever possible, but not offered "as a panacea for all economic ills".

The Fourth Point, in short, is the opposite of the groundnut scheme. There is no attempt by huge investments of capital, machinery and skilled labour to clear a vast area of undeveloped country and make it yield food. The object will be to cover as large an area of the world as possible with American experts who will advise the local administration of all kinds how to make their countries more healthy and their lands more productive mainly by the introduction of technical methods which are relatively simple. The Americans feel that far more is to be gained as a "result of slow, patient efforts in teaching the farmers who reap with a sickle how to use a scythe, rather than a complex tractor".

Britain's Parliamentary and Scientific Committee held a meeting to discuss President Truman's Fourth Point in March 1949. Statements were made by the then Under-Secretary for the Colonies, and by Dr. Alexander King and Sir Ian Heilbron. The Committee welcomed the President's proposal and set up a sub-committee which presented an interim report in July 1949. This report recommended that the British Government should have conversations with the American Government, both to see how British science and technology can collaborate in the world-wide campaign involved and to consider how American technology and capital can assist our plans for improving the conditions of under-developed areas within British Colonial territory. A list of projects was given, including the following—geological surveys; tsetse eradication schemes, especially the need for bush-clearing equipment and aerial spraying equipment; production of animal fodder; development of irrigation schemes; medical research to encourage European immigration; survey of crops; utilisation of tropical timbers; study of disease vectors. The sub-committee emphasised the importance of the whole project being "a co-operative enterprise in which all nations work together through the United Nations and its specialist agencies". These are President Truman's own words although so far they have not been implemented. It was recommended that each country making a major contribution should be given its own sphere of 'fourth point' influence.

The Parliamentary and Scientific Committee have not proceeded further since July 1949, as there appears to be no prospect of important developments in British-American collaboration over the Fourth Point programme in the near future. Since then, the Colonial Development Corporation have turned down an offer from the International Bank of £5,000,000 partly because it would involve too much interference and partly because in its view the help that could be provided would not be sufficiently substantial to be worth the risks involved. Moreover, it has become clear that the Americans are thinking in terms of exporting technological aid rather than capital. Therefore, there are not so great prospects emerging from the Fourth Point for the British Commonwealth and Empire as originally seemed possible.

Even in America the Fourth Point does not appear to be very popular. This is surprising for a country which is never afraid of big ideas. But although Secretary Acheson presented his plans in the most modest way, he did not get the reception from Congress which he evidently expected. He proposed a total authorisation of 45,000,000 dollars, but the amount was reduced by Congress by nearly half—20,000,000 dollars. It remains to be seen whether the Senate will help to increase the amount vouchsafed by Congress.

All this adds up to a disappointing beginning to the development of a great idea. One is reminded of the last words of perhaps the greatest of the imperialists whom it is now so fashionable to disparage and even ridicule: "So much to do, so little time to do it." The English-speaking peoples and "the freedom-loving democracies" will have to do a great deal more much more quickly if dire disaster is not to overtake their efforts to maintain their influence among the backward peoples of the world. President Truman, even when announcing his Fourth Point, seemed to be a voice crying in the wilderness. Little enough has been done since then. But both America and Britain have a habit disconcerting to their enemies of being favoured by good fortune and at the latest hour awakening and surprising themselves and everyone else with the intensity and success of their efforts. Another awakening is needed now.

Fish Migration

D. E. RIESER, D.Sc.

ALL fish travel, whether for food, better surroundings, or breeding grounds. Migrations which are of special importance are those long journeys regularly undertaken by certain fish to preserve the species. Fish such as the shark and the tunny travel alone or in small groups, constantly on the move in search of food, but other fish travel in big shoals. All these species are mainly controlled by temperature. Temperature can influence fish in two ways: either directly, as when fish leave the colder shore water for deeper water in the cold season, only returning to shallow shore water in the warmer season. Or else the influence of temperature is indirect, as when changes in sea currents or the cold influence the food supplies or plankton life on which many kinds of fish exist.

Only recent research has fully established the enormous influence of direct stimuli on migration. Temperature plays a major role in this respect and will be further dealt with in connexion with eel migration. Warmth may stop migrating habits altogether; the sea trout, for instance, normally goes to sea and enters rivers to spawn, but in the Mediterranean area it becomes an exclusively freshwater fish.

Herring and Mackerel

One fish which is constantly on the move, either in search of food or for spawning purposes, is the herring. Herrings migrate in immense shoals, and these moving shoals are followed by the fishing fleets. It is a well-known, although unexplained fact, that the densest shoals of herrings appear off the coasts of Britain and Ireland. Approximately one month before spawning, various shoals assemble for a short period once a year. Although the spawning season varies off the British coast, the shoals appear so regularly that fishermen can predict their whereabouts at a specific time with fair accuracy.

Spawning migrations are by far the most spectacular. The anchovy travels a long way from warm seas to spawn in the shallow waters near the Dutch coast, and the tunny leaves the Atlantic to go to the Mediterranean, each year to the same coasts.

The most interesting spawning migrations, however, are those undertaken each year by the salmon, travelling up their native rivers, and by the eels, which swarm in the opposite direction, going down the rivers to make their way towards the depths of the Atlantic. Recent research has clarified many hitherto obscure questions concerning these two species. The main emphasis in these studies was laid on the stimuli which guide migration. Scientists now take the view, that if more weight had been attached in the past to facts, and less to preconceived ideas of 'purpose', a true science of such movements would sooner have been reached.

Another important food fish with complicated migratory habits is the mackerel. Recent research work on this fish by G. A. Steven of the Marine Biological Association, Plymouth, has shown that apparently conflicting migrations among mackerel can now be explained. It has been discovered that all these fish have one common spawning ground, and do not spawn in the shallow, coastal waters as previously assumed. This spawning area lies in the open sea, approximately 100 miles to the west of the Scilly Isles, close to the 100-fathom line, which in this area marks the beginning of the deep continental sea-bed. It was also found that many mackerel spend the winter months on the sea floor, along submarine slopes. Afterwards they spread and break into shoals which migrate to the spawning grounds. (See "The Mackerel: New Light on its Migrations", by G. A. Steven, DISCOVERY, March, 1949.)

The mackerel in the North Sea also spawn on grounds in the vicinity of the 100-fathom contour which, however, are much closer to the shore in this area.

According to available information, it seems most likely that American mackerel follow essentially the same pattern of migration.

Salmon

The life of the salmon is spent partly in the sea, where it grows, and partly in freshwater, where it spawns and spends its youth. Migratory habits vary a great deal from one river to another. The life history of the salmon has been traced in great detail by observing the movements of a large number of marked fish in several countries. Thus it has been proved that most salmon return to spawn in the rivers where they were born. This, however, is not an invariable rule, and, if opportunity offers, salmon are quite prepared to invade new rivers.

From the study of the scales of salmon it has been possible to see that some fish in some rivers spawn only once in their lives, others spawn every year, others again every two years. Their scales bear concentric rings similar to tree rings. In summer food is abundant and growth is rapid, so that the rings are wide. In winter growth is slower and the scale rings are therefore narrow. There is

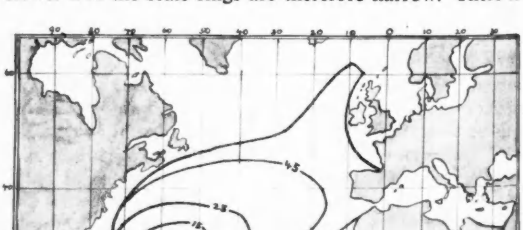


FIG. 1.—The eel-bridge across the Atlantic. This diagram indicates the distribution of the larvae at different stages of development. Leptocephali smaller than 10 millimetres long are localised in the inner circle around the breeding grounds; concentric rings indicate the sizes reached (15, 25, 45 mm.) along the migration route.

no growth during the spawning season; the fish wastes away and this is indicated by a frayed edge on the scales.

The life of the salmon at sea has been studied in Norway by Dahl, in Scotland by Menzies, and more recently by Dr. Hansen in Canada. It was seen that salmon migrate from their rivers to specific grounds in the ocean where they find abundant food and grow fat; afterwards they return at definite seasons to the rivers to spawn. They do not appear to go very far from the coast or to move into very deep water. Marked fish in Scotland were usually found within fifty miles of the place of marking. Salmon are, however, seldom caught in nets at sea, and some points about their migration still remain to be clarified.

Adult, sexually maturing salmon may enter freshwater at any time of the year. They may be young fish, about three years old ('grilse'); or fish which are older, coming to spawn for the first time (maiden salmon); or else fish which have already spawned before. The majority of salmon enter the estuaries between spring and autumn, and spawn in the winter months. The period spent in freshwater before spawning varies considerably, and during this time they do not feed. The fish swim upstream until they reach the spawning ground where the water is shallow and swift; the salmon is a powerful swimmer, and its ability to jump over small waterfalls is well known; the normal height of jump, however, rarely exceeds about 6 feet.

Recent observations have clarified the spawning procedure. On the spawning grounds the fish pair off. The female scoops a shallow trench in the gravel with her tail fin and lays her eggs, which are immediately fertilised by the male. The eggs are then covered with gravel, and the whole procedure is repeated in other spots until all eggs have been deposited. Once spawning has been completed the spent fish ('kelts') make their way back to the sea. They are lean, in poor condition, and do not feed or grow again till they reach the sea.

When the young fry are about 2·5 cm. long, and after the yolk sac on which they subsist at first has been absorbed, they begin to feed on their own. They are now called 'parr', and their bodies are marked with a number of spots. After about two years in freshwater, the 'parr' turn into 'smolts' with a silvery coat, identical with the adult salmon.

The period elapsing until the smolt stage is reached varies considerably. In some northern Norwegian rivers, for instance, the 'parr' take up to five years to become 'smolts'.

During the summer they go down to the sea where they feed voraciously and, accordingly, grow at a great rate. The average weight of smolts is about 3 oz., and that of grilse 4 to 5 lb. One year after leaving the rivers most grilse return to them, but many of them do not spawn in the first season. Again, others do not return to the rivers for four to six years when they spawn for the first time.

The Eel

The life history of the eel has been the subject of speculation, and later of research, from the time of Aristotle onwards. The most elementary fact known to the fishermen of classical Greece was that eels descended their rivers regularly every autumn and then disappeared into the open sea.

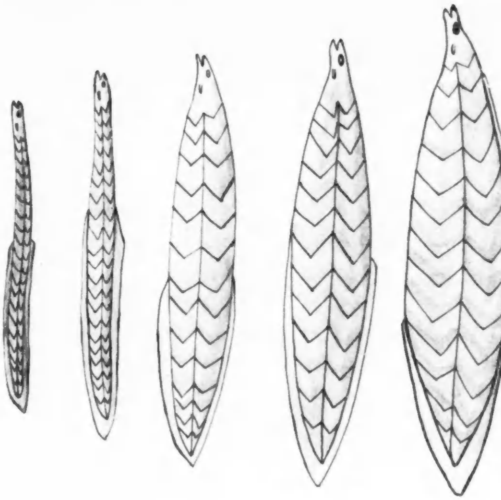


FIG. 2.—Transformation of Leptocephali into elvers.

It has also been known for a long time that large numbers of young eels, or elvers, appear in summer at the mouths of rivers and swarm upstream in a dense mass; these elvers are capable of penetrating even to land-locked ponds. The elvers are about 5 to 7 cm. long and about as thick as a piece of string.

The beginning of modern research into the life history of eels was the demonstration by two Italian biologists, Grassi and Caladruccio, in 1893 that the small, transparent fish, first studied under the name of 'Leptocephali' ('thin heads') were, in fact, eel larvae (Fig. 2). They are shaped like willow leaves, and quite unlike the elvers into which they develop. The transition of Leptocephali into elvers was reconstructed from observation of the many specimens brought to the surface by whirlpools in the Straits of Messina.

The geographical facts of migration were later established by the work of Danish investigators, beginning with the annual movement of adult eels down the Baltic, of which Danish fishermen had long taken advantage. By marking experiments, it was proved that individual eels covered between 20 and 100 kilometres in a day. At present this is still the best information on their speed of movement, for between the coastal waters of Europe and the Sargasso Sea no live adult eels have ever been captured.

Further discoveries were made about the larval stage of development. On a series of expeditions between 1909 and 1920, Johannes Schmidt traced the course of returning larvae which showed that an 'eel-bridge' existed across the Atlantic (Fig. 1). Surface collections were made farther and farther to the west, and it was found that the size of the larvae became progressively smaller and the number more abundant. The smallest and youngest were found over deep water, about half-way between the Leeward Islands

[Continued on p. 201

RADIO A

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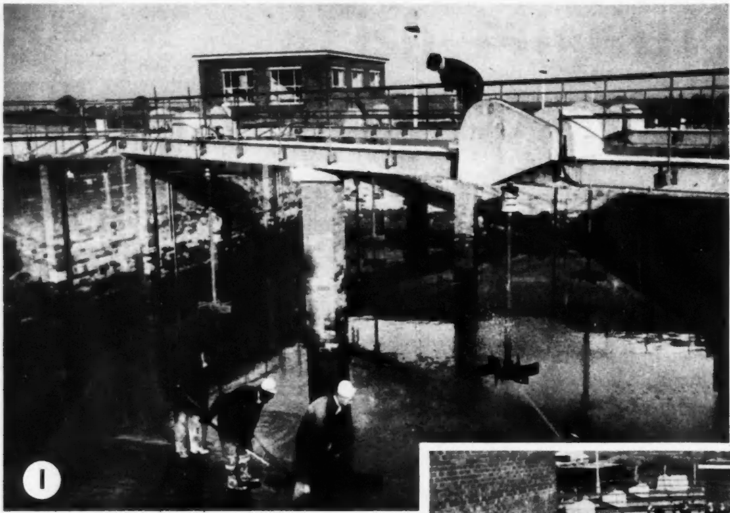
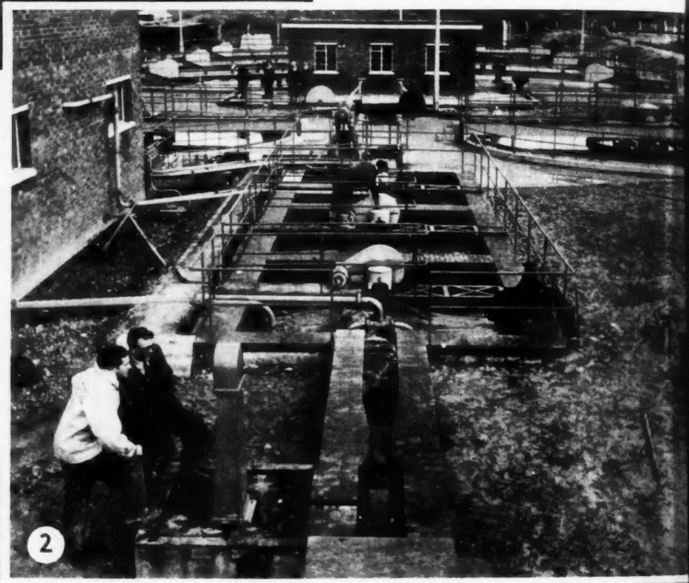
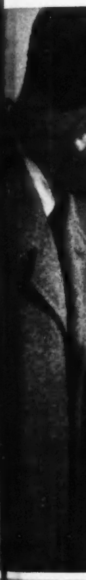
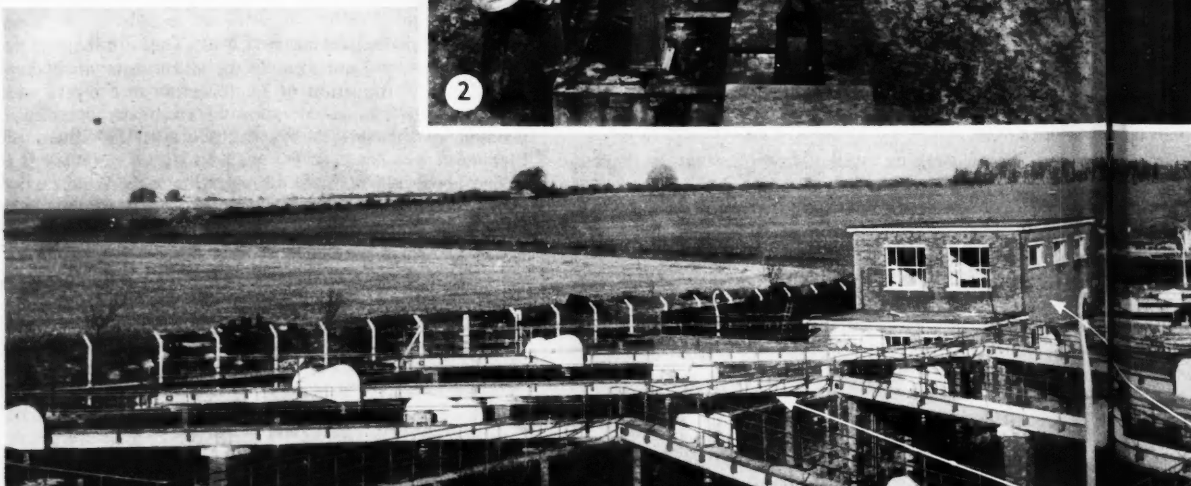


1. How to dispose of radioactive waste safety is on
logical problems of the atomic age. Harwell all th
atomic piles and hot laboratories have treated to
to a safe level before it is released in the Thames.
large effluent tanks in which radioactive waste water is
which can be seen in this picture are then settled.
tanks is used while the other is being



2. There may be many types of radioactive chemicals in the water. These have to be precipitated by adding chemicals to the water; for instance, soda ash (sodium carbonate) will throw out radioactive metals such as radio-iron as insoluble carbonates. This is done in what are called dosing chambers.





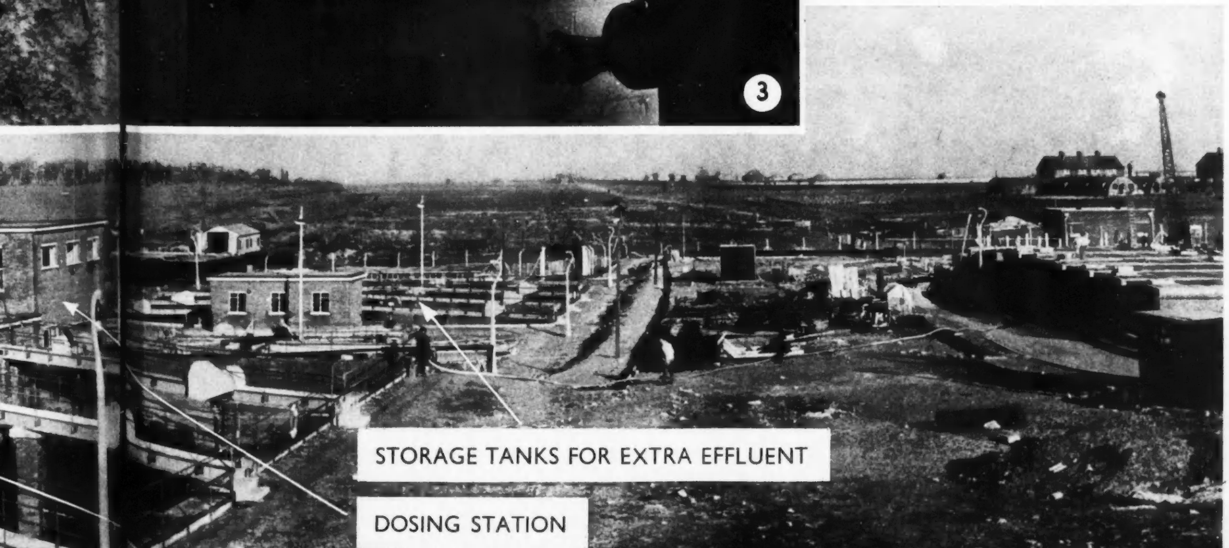
O ACTIVE

SEWAGE

radioactive waste safety is one of the biggest techno- the atomic age. Harwell all the waste water from the t laboratories have to be treated to reduce its radioactivity e it is released into the Thames. There are two series of in which radioactive waste water is first stirred by the fans in this picture and then settled. One series of settling ks is used while the other is being cleaned.

4. The sludge tank. After leaving the dosing chambers the Harwell water enters the sludge settling tank where the precipitated sludge is drawn off.

3. The dosing is checked. The head of the effluent works and his foreman check that the dosing of the water with chemicals to precipitate radioactive substances is proceeding satisfactorily.



5. The radioactive sludge is drawn off from the sludge tank and placed in large lead barrels. One of the problems facing Harwell is the eventual disposal of this possibly dangerous sludge.

6. The waste water now considered sufficiently free of radioactivity to be discharged is pumped from Harwell to the Thames nearly six miles away. The power to do this is provided by a subterranean power station.

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8. Harwell's water enters the Thames. The Atomic Energy Research Establishment uses a quarter of a million gallons of water each day. This is released into the Thames through a special weir in order to ensure thorough mixing of the Harwell water with the river water.

9. The mud and water below the weir are tested. Even after the water is released into the Thames a further test is carried out in order to ensure that neither the river water nor the mud carry dangerous amounts of radioactive substances.

7. Before the water is finally released into the Thames a final sample is taken in order to make sure that no dangerous quantity of radiation is present. This sample is carefully examined at Harwell before the final order for the water's release is given.

Readers have been asking for an article describing how the new electronic organ of the B.B.C. works. This article has been written to meet these requests; the subject is treated as simply as possible, but inevitably the explanation of the organ's mechanism demands somewhat more technical treatment than is favoured in the general run of DISCOVERY articles.

The Electrophonic Organ

C. L. BOLTZ

THE recent installation of a three-manual pipeless organ, the Compton 'Electrone', in the Maida Vale studio of the B.B.C. marks a significant stage in the evolution of electrophonic musical instruments, i.e. instruments in which the sound is generated electrically. During the past year one Electrone has been completed in the factory every week. So it is an accomplished fact of industrial production, and not, as in so many cases described at different times in the past half-century, just an experimental novelty. The earliest of the attempts was described in 1897 when Cahill was granted British Patent No. 8725 to protect his invention of a complete instrument of organ type, but financial difficulties prevented its commercial realisation. And he was working before the thermionic valve came into production (from about 1915 onwards) to provide a reliable method of amplifying small oscillations, and before the moving-coil loudspeaker was being produced commercially (from about 1925 onwards) to give inventors a ready method of converting electrical oscillations into audible sound. So it can be said that electrophonic instruments have been practicable only in the past twenty-five years, available (in small numbers) for about twelve years, and in steady production in Great Britain for a still shorter time.

The electrical generation of musical sounds offers two possibilities: it can be used to imitate traditional instruments, or it can be used to create sounds of entirely new quality, never heard before. It may be that a composer of the future will make use of this second possibility, but the type of instrument to appear so far is that in which only the first possibility has been realised. And of all the known instruments, the one on which the attention of designers has been concentrated is the organ.

The reasons for this are both aesthetic and economic. The organ, so often described as the King of Instruments, has its own grandeur of tone, and is the only single instrument that can be used to simulate a full orchestra qualitatively and quantitatively. The pitch range is enormous and there is great flexibility in its use. This is achieved by having in effect more than one organ, each of which has a keyboard or *manual*; a *pedal* keyboard provides the deepest tones, this being played by the feet. The whole arrangement of manuals and pedal is the *console*, to be distinguished from the sound-producing part—in a pipe organ, this is the assemblage of pipes—which may or may not be near the console. The insertion of *stops* on the console allows combinations of pipes of chosen tone-colour to be played together. Most organs have at least two manuals and a pedal. In such an instrument, to give an example, the upper manual (the *swell* or *solo*) can be 'stopped' to voice oboe-like tones while the lower manual (the *great* or *accompaniment*) can be 'stopped' to voice flute-like tones, the pedal being 'stopped' for diapason tones. The organist can then play oboe-like upper melody against flute-like accompaniment and diapason deep bass. There are many possible arrangements of stops with highly specialised (and unusual) names that were coined during the evolution of the instrument over the past several centuries. These facts indicate why a good pipe organ consisting of hundreds of pipes, each made and 'voiced' by a craftsman, with a complex array of stops, is very expensive to build, occupies great space, and is a fixture. Furthermore, pipes depend for their sound on air forced through them, so humidity and temperature affect the quality and pitch, and so do dust and chemical deposits. In fact the tuning of a very large pipe organ can be nearly a continuous task. In contrast, an electrophonic organ will stay in tune almost indefinitely with only occasional servicing, is much more compact, is comparatively portable and is much less expensive.

When considering electrophonic instruments we can take the loudspeaker end for granted and concentrate on the method of generating and controlling the electrical oscillations. Before doing so we must understand the scientific aspect of difference in tonal *quality*. A note played on the piano sounds quite different from the same note played on, say, an oboe. This difference has been traced to two facts: (*a*) the complexity of the sound-wave producing the sustained tone, (*b*) the transient waves (i.e. waves of extremely short duration) at the beginning and end of the

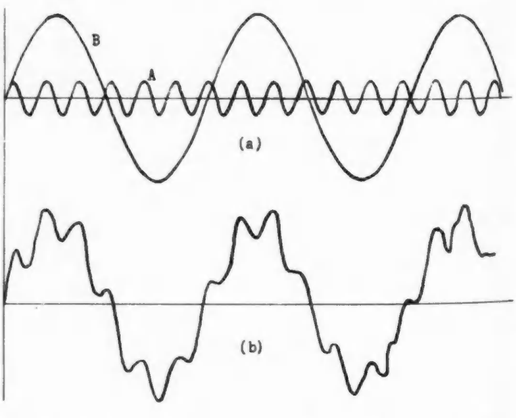


FIG. 1.—(*a*) shows two sine curves, *A* having a frequency 6¼ times the frequency of *B*, but only a fifth of *B*'s magnitude. (*b*) shows the two curves added, giving a complex curve. *B* corresponds to the pure tone of a tuning fork and *A* to the vibration caused by a sharp knock on the fork with a hard object, giving the 'clang' tone represented by the complex curve of (*b*). The horizontal axis represents time and the vertical axis magnitude. The shape of the curve in each case can also be called the 'wave-form'.

sounding of the note. Both these can be analysed into a summation of 'pure' tones, i.e. tones whose wave-forms are sine curves (see Fig. 1). So every sound consists of a summation of pure tones, though the transients are short-lived. The tone with the lowest frequency is called the *fundamental*, and the rest are *overtones* or *partials*. With many musical sounds—but not all—these overtones have frequencies that are exact multiples of the frequency of the fundamental; they are then called *harmonics* and usually run in series while decreasing in amplitude. The harmonic with double the frequency of the fundamental is the *second* harmonic; that with treble the fundamental frequency is the *third* harmonic, and so on. Thus a sustained tone of any desired quality can be produced by adding together pure tones to give the correct combination of frequencies and magnitudes. This synthesis achieves only the sustained tone quality, not the attack and decay. Fortunately for the designer of an electrophonic organ, however, it is on the whole the sustained tone of organ notes that is most important, for the attack and decay are smooth enough to be imitated approximately without great difficulty by means of the charge and discharge of a condenser through a resistance (see below). Moreover, when the designer wishes to imitate, say, string tones, he need only consider the pipe-organ simulation of these tones, not those of the actual stringed instrument. To illustrate this discussion, Fig. 2 is given. It shows the graphed results of the analysis of two sustained tones made by pipe organs, (*a*) being for diapason and (*b*) for a trumpet tone. These results are not shown as wave-forms but as 'spectra', i.e. the relative quantity of each harmonic component is set out according to frequency, starting with the fundamental. We can see that the decrease in quantity falls on a fairly smooth curve. We can also see that the lower harmonics are not necessarily of less magnitude than the fundamental. Both these observations help us to understand what a designer of an electrophonic instrument has to do. He can use pure tones, and add them together in the correct quantitative relationships, or he can create outright complex wave-forms of suitable shape like the very simple one shown in Fig. 1 (*b*). The first alternative makes an inordinate number of pure tones necessary for building up several octaves of various tones, while the second alternative necessitates a very accurate delineation of wave-form, any inaccuracy in a small-scale drawing having important results in the final tone. The designer of the Electrone has used an ingenious compromise between the two extremes, as will be seen below.

In the above discussion it has been taken for granted that everyone today knows that the pitch of a musical note depends on the frequency, i.e. the number of waves per second. The higher the frequency, the higher is the pitch. We can hear notes whose frequencies range from about 20 cycles per second to about 20,000 cycles per second. This we call the *audio-frequency* range. In the discussion now to follow the term *capacitance* is used several times. This is a property of a *condenser*, which in essence consists of two metal plates separated by insulating material. When a battery (or a direct-current, or D.C., supply) is joined to the plates of a condenser, a charging current flows and energy is stored in the condenser. The current ceases when the electrical pressure of the condenser is equal to that of the battery. The time taken for this equilibrium to be

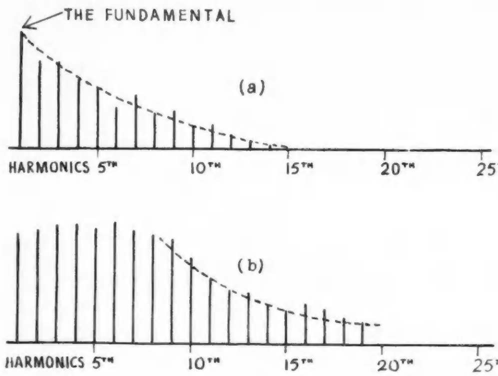


FIG. 2.—Spectra of two organ tones, the harmonic number being on the horizontal axis and relative magnitude on the vertical axis. The dotted lines suggest the approximate smooth curve according to which the magnitudes fall off. (*a*) is open diapason and (*b*) organ trumpet tone. (Drawn after examples in a paper by C. P. Boner.)

reached can be altered by changing (*a*) the electrical resistance of the circuit, (*b*) the geometry of the condenser. It is this geometry (area of plates, their distance apart, etc.) that is expressed in the term *capacitance*. When the battery is removed and replaced by a conducting wire, the condenser discharges. The rate of discharge also depends on the resistance and capacitance of the circuit.

Several methods, in theory at any rate, are available for the generation of electrical oscillations at audio frequency.

(1) There is the well-known valve oscillator in which the frequency depends on the inductance-capacitance value of the oscillatory circuit.

(2) There is the neon 'clock', well known to physics students, wherein the charge and discharge of a condenser is made to occur at audio frequency by the correct choice of resistance and capacitance.

(3) A reed may be maintained in vibration at its natural frequency while an either electromagnetic or electrostatic pick-up, mounted near by, produces electrical variations corresponding to the vibrations.

(4) A beam of light scans a reflecting or transparent wave-form, the resulting variations in light intensity being transformed into electrical variations by means of a photo-electric cell.

(5) A wheel of ferromagnetic material, with its periphery shaped according to the wave-form desired, is rotated edge on to the pole-piece of a magnet surrounded by a coil of wire. As the wheel rotates, changes in the magnetic field cause corresponding varying currents in the coil.

(6) A metal wave-form on a flat disk is held opposite a rotating metal arm and separated from it by air, thus making a condenser whose capacitance is varying according to the wave-form. The varying capacitance can be changed into varying voltage in a way shortly to be shown.

All the above methods have been used at one time or another, but only three have so far emerged as possible production methods for organs, namely (1), (5) and (6). The first necessitates an enormous number of thermionic

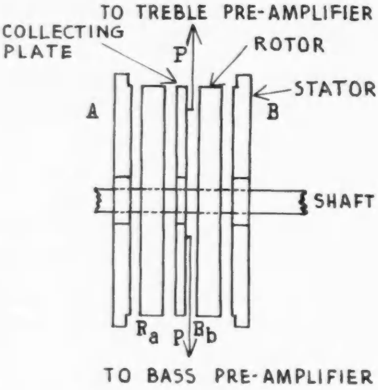


FIG. 3 (*above*).—Section of one generator of the Electrone. *A* and *B* are the stators, R_a and R_b the corresponding rotors, and *P* the pick-up plate. Only R_a and R_b rotate.

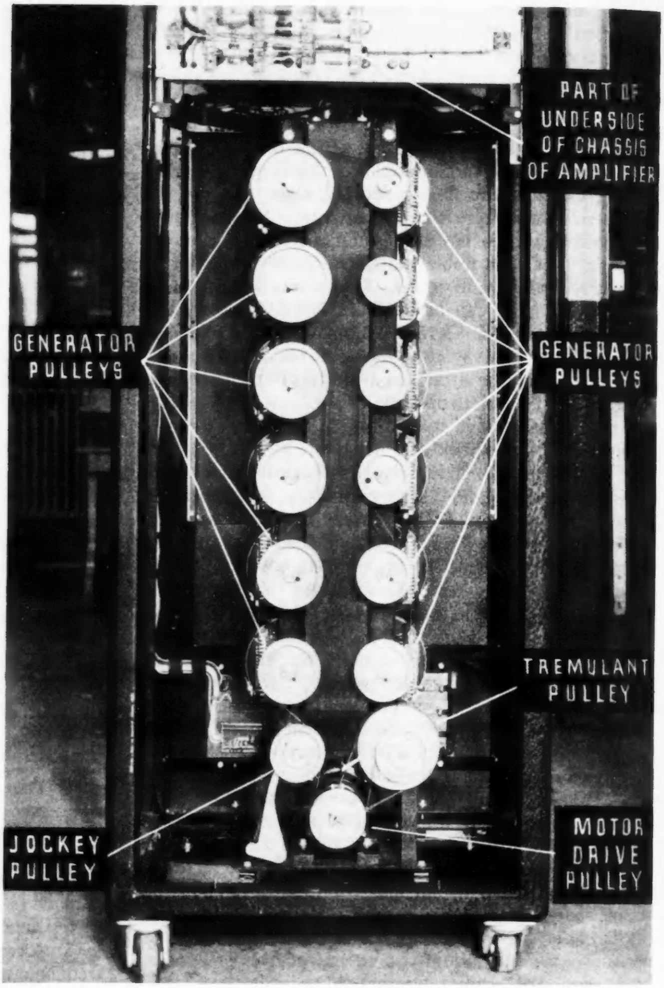
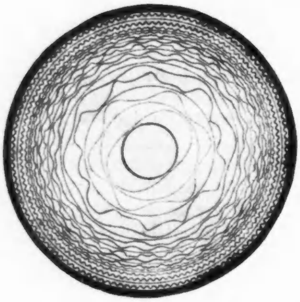


FIG. 4.—View of front of generator cabinet showing the top twelve generator pulleys, the left bottom jockey pulley, the right bottom tremulant pulley, and the driving pulley of the motor right at the bottom. At the top can be seen part of the underpart of the chassis of the amplifiers.



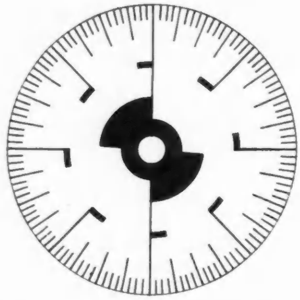


FIG. 5 (*left*).—A stator, part of the Electrone's generator. The light parts are metal and the black, insulator. From the inside edge outwards 21 separate metal areas can be counted. Eight of these are earthed and so contribute nothing to the generation of *formants*. In the stator illustrated there are four sets of formants. Fig. 6 (*right*).—The generator rotor corresponding to the stator of Fig. 5. The black patches and lines indicate raised portions that 'scan' the wave-forms on the stator.

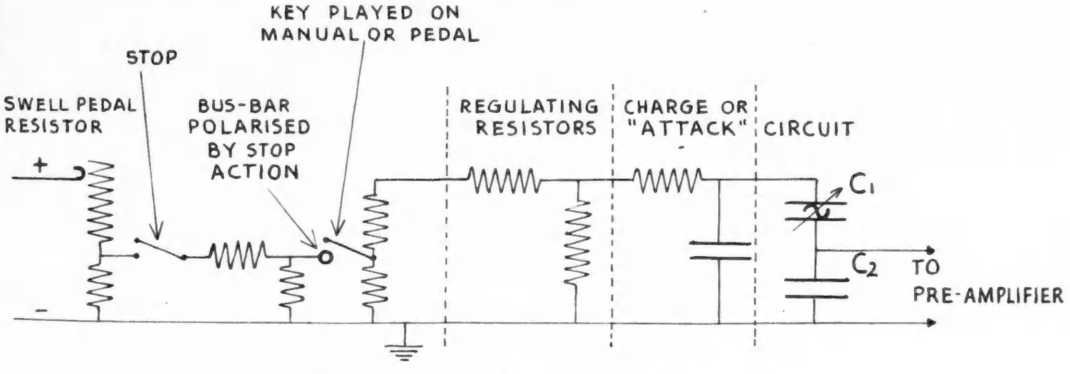
valves. One British firm is said to have produced an organ of this sort and to be about to produce more, but it is not in production in the sense that the other two are—(5) and (6). Method (5) or a variant is used in the well-known Hammond organ, quite a number of which exists in this country. They are all made in America. The only British firm in production is the John Compton Organ Co., utilising method (6) invented by L. E. A. Bourn. It is an organ of this type, specially made and fitted with extra devices (there are three manuals and a carillon), that has been installed for the B.B.C.

The inventor has overcome the difficulties of the two alternatives already mentioned above by devising four complex wave-forms that he calls *formants*, which can be combined to produce any needed sustained organ tone of one fundamental. These formants are: (i) the 'prime', whose wave-form is mainly that of the fundamental, and therefore gives a nearly pure tone; (ii) the 'short odds', whose wave-form is made up from the 3rd, 5th, 7th and 9th harmonics added together; (iii) the 'long evens', whose wave-form is made up from the even series of harmonics from the 2nd to the 32nd; (iv) the 'long odds', with a wave-form made up from the odd series of harmonics from the 3rd to the 31st. (These formants can be seen inscribed on a stator in Fig. 5.) This separation of the prime as nearly a pure tone enables a combination to be made in which the fundamental is smaller in magnitude than the lower harmonics, as was the case with the trumpet tone illustrated in Fig. 2 (*b*). With the other three formants the magnitudes of the harmonics fall off according to a smooth curve as already suggested in Fig. 2 (*a*) and (*b*). There are eight sets of these formants, going up in octaves, to one generator. That is to say, the first set is the lowest in frequency, the next set an octave higher, and so on. There are twelve such identical generators, but their speeds are arranged in sequence in such a way that the lowest prime of any generator is a semitone higher than that of the generator behind and a semitone lower than that of the generator ahead. This sequence of twelve speeds makes a chromatic octave if we think in terms of only one note on a generator—the lowest prime, for example. But there are eight primes to each generator, each prime an octave higher than the one before it, and so in this way the whole range of eight chromatic octaves of primes is covered. The remaining formants are used in combinations to create the quality needed. The combining is effected by the player by means of stops on the console, and these operate electromagnetic devices that switch on to the appropriate formant circuits the electrical supply used for generating. The keys used by the player are also really switches in the electrical sense.

Construction of the Generators

Each generator consists essentially of five parts, as shown schematically in Fig. 3. *A* and *B* are the two stators facing inwards towards the rotors R_a and R_b. The generator voltage is induced on the collector plate *P*, which has two connectors. (In this way the use of brush connexions on the rotors is avoided.) Forty or so connexions are made through the backs of the stators to the active generating sections and the earthed sections. The generators are driven by one 1/8 h.p. motor, the different speeds being achieved by means of an endless belt running round pulleys of different sizes. A jockey pulley keeps the belt in tension, and an extra eccentrically mounted pulley can be brought into action to vary the speed of the belt and so produce a tremulant effect. All these pulleys are seen in Fig. 4, the motor being at the bottom, the jockey pulley at the bottom left and the tremulant pulley at the bottom right.

One-half of a generator is shown in Figs. 5 and 6, i.e. one stator and one rotor. On the stator the black lines are



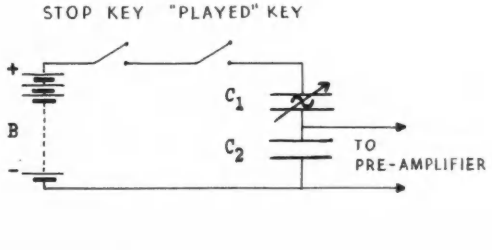


FIG. 7 (*right*).—Circuit for explaining the action of generating an alternating voltage when the rotating condenser is polarised by a D.C. supply. C_1 represents one section of a stator and its rotor scanner, C_2 represents earthed capacitance formed by the rotor and earthed sections of the stator as well as stray circuit capacitance.

FIG. 8 (*above*).—The circuit of Fig. 7 expanded to show the charge or 'attack' circuit, the regulating resistors, the swell-pedal variable resistor, the bus-bar polarised with D.C. when a stop is pressed, the key that closes when a key on manual or pedal is pressed down in playing, and the resistors that make up potential dividers and take part in the discharge or 'decay' and in combining voltages in the right proportions to produce accurate power outputs.

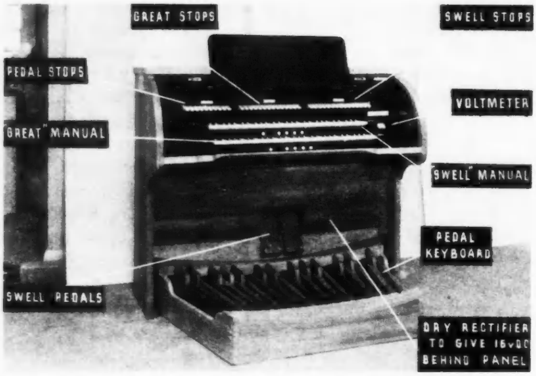


Fig. 9.—The console of the Electrone organ, two-manual type. Both manuals and the pedal are seen; also the stops, one group for each manual and for the pedal. A 16-volt D.C. supply is obtained from a dry rectifier behind the panel to the right. This low voltage is used to operate the electromagnetic 'relays' that switch on the high voltage in the generator cabinet when stops and keys are used. Thus all high voltages are kept away from the console.

engraved through a metal coating on a bakelite disk, and so are insulating lines, the active sections being the metal parts between circles and curves. Some of the sections are earthed. Anyone can trace out from the illustrations the successions of formants. The rotor consists of an insulating disk coated with metal. In theory one radial ridge would do, but certain practical difficulties into which there is not space to go here make the broadening and multiplication of ridges necessary.

Varying the Voltage

The way in which an electrical oscillation is created can be understood from Fig. 7, which is purely schematic. The battery shown is in practice a D.C. supply of 400 volts from a power pack. The generating condenser is C_1. The other condenser shown is really the earthed condenser made by the earthed stator sections and other stray capacitances. This is labelled C_2. It is the addition of the polarising D.C. voltage that creates the oscillating voltage. Without this voltage the varying condenser C_1 creates nothing. Consequently all the generators can be left rotating all the time and only create musical notes when polarised by both a stop key *and* a played key on manual or pedal. In the circuit shown, immediately the battery is switched on the condensers charge up to the battery voltage. But if C_1 varies, then the amount of charge varies correspondingly, and a charge varying in time constitutes an alternating current. Thus an alternating current flows round the circuit consisting of battery and condensers. An alternating voltage thus appears across C_2, and it is this that is amplified in the pre-amplifier and the power amplifier. Actually, if the circuit were as simple as the one shown, the sudden creation of the A.C. would make a bad grunt every time a key was depressed, and also a very sharp attack to the musical note. So a resistance-capacitance circuit is added between key and generator, and by suitably calculating the values of resistor and condenser the designer can make the attack simulate the build-up of a pipe-organ note. When the key is released the condensers discharge, and by adding other resistors this discharge can be made to last any desired time, and so the decay of the musical note is adjusted. The loudness of the note depends on the size of the polarising voltage. Consequently a means is provided for subdividing this voltage both permanently and at will. As a consequence a more practical schematic circuit is as shown in Fig. 8, where the variable resistor represents the swell pedals and the regulating resistors represent the permanent adjustment of voltage for the generator. For minimum sound, about 2 volts is applied to the generator, and this can be increased by means of the swell-pedal resistor to about 200 volts. The resistors other than the regulating ones and the charge circuit are used for further voltage subdivision, for the discharge, or decay, circuit and for making sure that when two keys are depressed on one note, the voltage is not doubled but increased in the proportion of 1 : 4, because the power output from the amplifier is proportional to the square of the amplified voltage. As there are some forty keys in each manual and rather less to a pedal, with eight or more stops to each as well, the resulting networks of resistors and condensers and relays is very complicated, and will not be given here. Even with the charge circuit inserted, the key 'grunt' is still troublesome at higher frequencies. So the generators are arranged so that all the lower frequencies, the bass, are towards the innermost part and the higher frequencies, the treble, towards the periphery. These are picked up on two separate leads, as already mentioned, and passed through two separate pre-amplifiers, one for treble with a lower cut-off at about 250 cycles per second, and one for bass with an upper cut-off at about 250 cycles per second. Thus in the treble the key 'grunts' are eliminated and they are not found troublesome in the bass. Both treble and bass are further amplified in power amplifiers and then transferred to two loudspeakers.

In the resulting organ there are three assemblies: the console, the generator cabinet, the sound cabinet, all connected by cable. The first of these is illustrated here. As far as the player is concerned, the console is quite orthodox, with the customary manuals and stops and swell pedals and pedal keyboard.

This discussion has been restricted to elementary principles and space will not allow us to go into the many refinements and ingenuities used to produce a final effect that is aesthetically satisfactory. (It is doubtful if any designer of electrophonic organs would claim that his instrument is *better* than a really first-class pipe organ. It is where space and money are limited that the instrument comes into its own.) It can be said, however, that in the organ installed for the B.B.C., the carillon effect is achieved by making the attack abrupt and the decay slow, thus producing the initial bell clang and the slowly dying hum, while the formants are combined in an inharmonic series. In the standard model described, only organ tones are simulated. For work where exotic effects are desired, as in cinemas, the circuits would have to be still more complex.

The Bookshelf

The Sea and its Mysteries: An Introduction to the Science of the Sea. By John S. Colman. (Bell & Sons, London, 1950, pp. 285, 12*s*. 6*d*.)

THE science of the sea is a fascinating subject, but there are few who have written about it in quite so charming a way as Mr. Colman has in this little book. He has been able to write from first-hand experience about the various aspects of research, and he has travelled far in a variety of vessels, observing everything with the alert eye of a yachtsman and biologist, and interpreting what he saw with a scientist's mind. Mr. Colman (who has just been appointed director of the Marine Biology Station at Port Erin) covers a very wide field, he starts with a brief, but very interesting account of the early history of navigation, then come chapters on the physical and chemical aspects, on waves and tides and the circulations of water masses. There are several excellent chapters on the biology at various depths and on the sea shore, and there is a brief account of the aims and methods of oceanographical research. It must have been very difficult to decide what to include from so vast a field of knowledge, and it is remarkable how much has been packed into a small book by skilful arrangement and the careful choice of words; and it is gratifying to find that many exciting discoveries following war-time research have been included. His descriptions are vivid, accurate and easy to follow, that of the winds and waves of the Great Barrier Reef and their effect on the emotions as well as on the coral is an example, another is the up-to-date account of the complex circulations of the water masses which are described so simply in terms of well-known properties of matter that the reader not only follows the argument but feels that he will be able to remember the details. There is an excellent index, a map (which is useful but hardly comes up to the aesthetic level of the rest of the book), a number of good photographs and clear line drawings, and a coloured frontispiece which only those who have never seen living coral may think too lurid.

J. P. HARDING.

Modern Arms and Free Men. By Vannevar Bush. (London, Heinemann, 1950, pp. 300, 10*s*. 6*d*.)

WHEN a scientist of the calibre of Dr. Bush, who was chairman of the war-time National Defence Research Committee, and in charge of the Manhattan District Project, undertakes an examination of the process by which science is affecting the nature of war, the result is bound to be an important book irrespective of its literary merits. It is all the more important, because we can accept from him many conclusions which, in the absence of corroborative evidence still withheld for security reasons, we would take with a pinch of salt from many another man, even though some of these conclusions are startling enough. Certainly Dr. Bush is the first scientist at the highest official level to cast serious doubt on the absolute power of atomic weapons, and such a contention alone is bound to arouse the most lively controversy. In Dr. Bush's view, the development of guided missiles and proximity fuses has swung the balance in favour of defence, at least as far as atomic warfare is concerned, and "may yet bring a feeling of relative security to the world". "The days of mass bombing may be approaching their end." But they may not. There can be no guarantee that some new development will not counteract the guided missile and the proximity fuse, and detract decisively from their protective power. The whole history of the art of war is that of the continual swing of the pendulum between offence and defence. And in an age of swift technological changes it would be rash and dangerous to discount, however slightly, the power of as cataclysmic a weapon as the atom—or hydrogen—bomb on the assumption that the pendulum will remain fixed on the side of defence for more than a fleeting moment.

But possible differences of opinion on this score do not in any way detract from the value of this book. For it contains a wealth of information on scientific armaments—the only ones that matter today—which could hardly be found elsewhere. It stresses *inter alia* the fact, unfortunately obscured by the advent of the atom bomb, that at present the improved new submarine is as great a danger as any that confronts the Western democracies. In fact, as far as modern arms are concerned, the book is a veritable mine of information which students of international affairs and of war can only ignore to their cost.

Unfortunately, the same cannot be said of the part of the book which deals with free men or, to put it more clearly, with the process by which democracy is affecting the nature of war. Here Dr. Bush is on less sure ground, which is only natural for an eminent scientist who cannot be expected to devote more than his leisure moments to political cogitation. No economist, for example, would agree with him that Marshall Aid is "straining our resources to the limit and risking our entire economy"; and few students of politics would be sanguine enough to believe that the democracies have really learned a lasting lesson from Munich. Nor would they be as sure as he of the inherent superiority of democracy in the struggle between East and West. No doubt, Dr. Bush is right in stressing the fact that totalitarianism is not conducive to as effective performance in the field of science as is democracy. But science is only one factor, albeit an important one, in the balance of power. In a cold war, or war *tout court*, there are other spheres in which the innate superiority of democracy is anything but manifest. To say, as Dr. Bush does, that this superiority was demonstrated in the last war, is to ignore the fact that it took the combined resources of the major part of the world several years to overthrow one single totalitarian power.

But to the discerning reader these are minor blemishes. For he would naturally expect to learn more about the science of armaments than about the science of politics from Dr. Bush's book. And in this he will not be disappointed.

E. M. FRIEDWALD.

Giant Brains, or Machines that Think. By E. C. Berkeley. (New York, John Wiley; London, Chapman & Hall, 1949, pp. 270, 32*s*.)

To explain the workings of a modern automatic calculating machine to the lay reader at anything higher than the sensational newspaper article level is no easy task, though *Time* recently achieved the almost impossible with a brilliant article. Mr. Berkeley has made a bold, and on the whole successful, attempt to do so. His 'Simple Simon'—an automatic calculator reduced to its bare essentials—is probably the best possible introduction to the subject, though it is perhaps a pity, however, that he allowed himself only 19 pages to describe it. The result is that the steps of the argument have been compressed, and are difficult to follow even for one accustomed to think in mathematical and logical terms. Few readers will emerge from this key chapter with a full appreciation of its contents—which they might have obtained if the argument had been set out step by step at three times the length. However, the book is so designed that much can be obtained from the rest of it, even if this chapter and some other highly compressed sections are only vaguely appreciated. It is, however, a serious omission that the fundamental idea of *iteration*, on which all automatic calculations are based, is nowhere described.

The title is a bit of a shocker, but it was probably designed that way; moreover it is difficult to visualise an alternative title that would not be forbidding and cumbersome. These machines are not *giant* brains. They are *dwarf* brains, in the sense that they contain very many fewer 'nerve cells' than does a human brain. But—and this is their essential virtue—they are nimble dwarfs that work many thousands of times faster than the human brain. Once the title page is past, however, there is no cause to complain of sensationalism. The question, how much and in what sense these machines can be said to think, is discussed with moderation, and all the limitations of machines in existence are firmly stated. Mr. Berkeley does not concern himself much with future development, and one is inclined to feel that there would have been some value in an attempt to foresee some of the ultimate possibilities—for example, the automatic factory managed by an electronic brain, which would do everything except make basic policy decisions.

The Preparation of Weather Forecasts

J. F. KIRKALDY, D.Sc., F.R.Met.Soc.

THERE are three different types of weather forecaster. First in the field was the 'local expert', usually a farmer or fisherman, who by long experience has become very adept at foretelling weather conditions for a particular place. Second is the professional meteorologist, who considers, with the aid of his charts, a much larger area, perhaps a quarter of the earth's hemisphere. For aviation purposes he has to deal with many things, which do not fall within the popular concept of 'weather', such as the thickness of cloud layers, the height range through which ice accretion may occur, the direction and force of the wind at 20,000 feet. Both of these types of forecaster are usually only reliable for short periods, up to twenty-four hours ahead or slightly longer. But there is a third category, whose members strive to detect among the ever-changing distribution of weather conditions, periodicities and correlations which will enable them to forecast, even though only in general terms, for periods of a week or more ahead. This article deals only with the work of forecasters in the second category.

The primary tool of the professional forecaster is the synoptic map or chart, which shows in symbolical form the detailed distribution of weather conditions over a wide area at a given instant. Such charts cannot be constructed without the aid of an elaborate organisation; an organisation which must be of an international character. The synoptic meteorologist, whether preparing a forecast for the B.B.C. or for a transatlantic flight, must be able to refer to charts showing weather conditions over the whole of the North Atlantic and its surrounding land areas.

The data for synoptic charts are collected according to rules laid down by the International Meteorological Organisation, in whose activities British meteorologists have always played a leading part. Standard procedure has been devised for taking observations of weather phenomena at fixed times. The reports are then coded up in the International Meteorological Code (see Fig. 2), and sent by carefully supervised signal channels at fixed times to one or more collecting stations in each country. A selection of each country's reports is then broadcast at a given time and on an agreed frequency.

The organisation in use in Great Britain is shown in Fig. 1. The channels are in nearly every case two-way, especially on land, for while the meteorological office on an airfield must send in its reports, the forecaster there must also receive reports from the other stations to provide the data for constructing his working charts.

At 15 minutes to every hour trained observers at every full-time reporting station in the British Isles go out to make the standard observations (and some others) of the weather elements shown in Fig. 2. The observations are then coded up into a number of five-figure groups. With one figure for an element, for example Low Cloud, the presence of any of the nine types of Low Cloud, shown in the International Cloud Atlas, can be reported, while 0 or — means the absence of Low Cloud, that is of cloud with base below 8,000 ft. With two figures available, the direction of the surface wind can be reported correct to the nearest ten degrees and the weather at the time of observation can be referred to one of 99 categories. It is very slipshod reporting to send the code figures 60 for 'rain', for it is essential to know whether it was 'intermittent light rain' (61), 'continuous moderate rain' (64), 'intermittent heavy rain' (65), or 'rain falling through fog' (67). Barometric pressure is reported correct to one part in 10,000, that is to the nearest tenth of a millibar (1000 millibars are equivalent to the pressure of a column of mercury 29·531 inches or 750·1 millimetres in height), whilst great care is taken in reading the amount and nature of the change of pressure in the previous three hours. The use of the International Meteorological Code makes it possible to report with accuracy a great variety of weather conditions.

At the hour the Group Collecting Station will call up on the teleprinter each of its satellite stations in turn and will receive their coded reports, whilst the observations from coastguard stations and certain other stations will come in by fixed-time telephone calls. At five minutes past the hour the Group Collective Message should be complete, and it will then be teleprinted to the Central Forecasting Office (C.F.O.). By ten minutes past the hour C.F.O. will have received over the several teleprinter channels, the reports for the whole of the British Isles. A master switch is then altered and for the next 50 minutes all this information is broadcast by C.F.O. First come the British reports, taking some 20 minutes, then the reports received at C.F.O. by wireless, or via the Central Telegraph Office, from foreign countries, from aircraft, from liners and—a very recent addition—from the special meteorological ships. These reports will be interspersed with coded messages giving the results of radio-sonde ascents or the flights of the special meteorological aircraft (for an account of these see DISCOVERY, 1946, Vol. 7, pp. 262–9) and—partly in plain language, partly in code—the views of the senior forecasters at C.F.O. on the weather situation and its future developments. Just before the hour, the broadcast stops, the master switch is altered; C.F.O. is ready to receive the next set of reports and so the system goes on throughout the 24 hours.

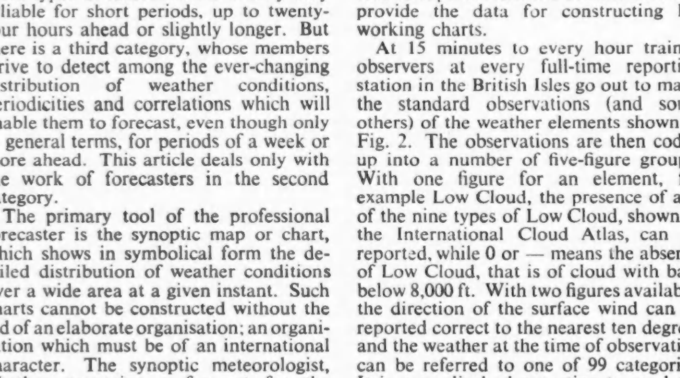


FIG. 1.—*The Communication Network for collecting weather observations. Links in the British Isles between the C.F.O. (Central Forecasting Office) at Dunstable, the Group Collecting Stations and their satellites are usually by teleprinter, more rarely by telephone. Reports from ships and foreign countries are received by wireless (broken lines), either directly at C.F.O. or via the Central Telegraph Office.*

Constructing a Synoptic Chart

At intervals of either 3 or 6 hours synoptic charts are drawn at all main forecasting offices. Trained assistants plot by hand the information received over the broadcast, entering each weather element in its prescribed form and colour (see Fig. 2) round the numbered circles marking on the charts the position of the different reporting stations. A well-trained assistant can plot at the rate of three stations a minute, using a black and a red pen tied together, and within about half an hour all the British reports will be on the chart. The chart is then handed over to the forecaster who commences to analyse it by drawing isobars (lines joining all places with the same sea-level barometric pressure) and fronts. As additional information is received, for example the reports from ships and foreign countries, it is entered on the chart and the analysis is extended. The forecaster is constantly comparing the chart on which he is working with those showing the reports for six or twelve hours previously.

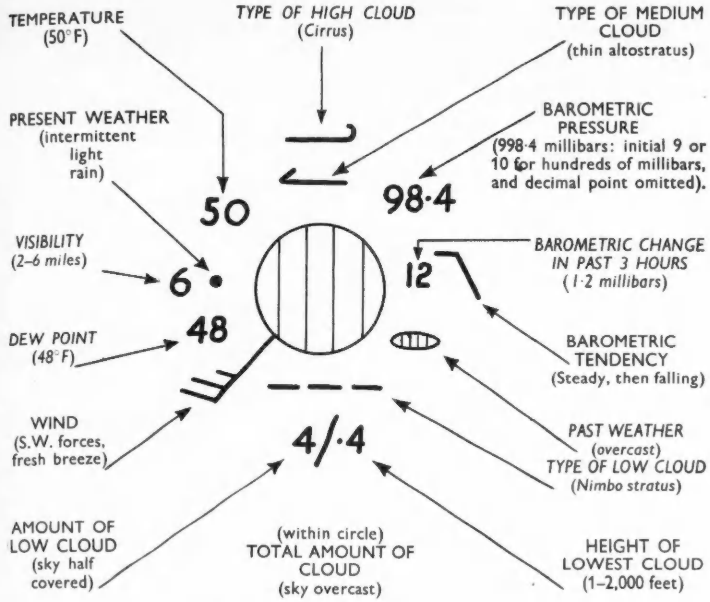


FIG. 2 (*left*).—*International Meteorological Code of symbols used to record weather conditions on charts. This diagram shows some of the symbols, and the systematic order in which they are plotted round the circle representing the reporting station.*

In this way he can see if the situation is developing as anticipated or if some unforeseen change is taking place. While the forecaster is working on the chart, the assistant will be plotting on special forms the results of radio-sc nde and aircraft ascents. These in conjunction with the chart of surface observations give a three-dimensional picture of the structure of the atmosphere. From the ascents special charts can be constructed to show the pressure distribution and hence the direction and force of the winds at any required height. It will be several hours after the observations have been made before the chart on which they are plotted is finally complete, but by maintaining a series of charts, complete or partially complete, the forecaster has readily available the latest information from any part of the area with which he is concerned.

It must be remembered, though, that the forecaster is not working in the calm of a research laboratory. Telephones may ring or callers enter and distract his line of thought with inquiries which must be answered, while he must always keep one eye on the clock for there are routine forecasts to be issued at fixed times. If vital information is lacking, perhaps owing to the temporary failure of one link in the communication chain, the forecaster usually cannot wait for it, but must make the best estimate that he can with the information before him.

The isobars which the forecaster draws on his chart indicate the areas of excess atmospheric pressure (anticyclones or highs) and of pressure deficiency (depressions or lows). Much more significant, however, are the fronts which he inserts. They mark the dividing lines between air masses of different origin and history and hence with different physical properties. It is along fronts that thick rain-producing cloud is most likely to occur.

If Tropical Air (that is, a great volume of air which has stagnated for several days in the tropics and returned northwards as a very warm and moist airstream) flows past Polar Air, dry and cold and therefore

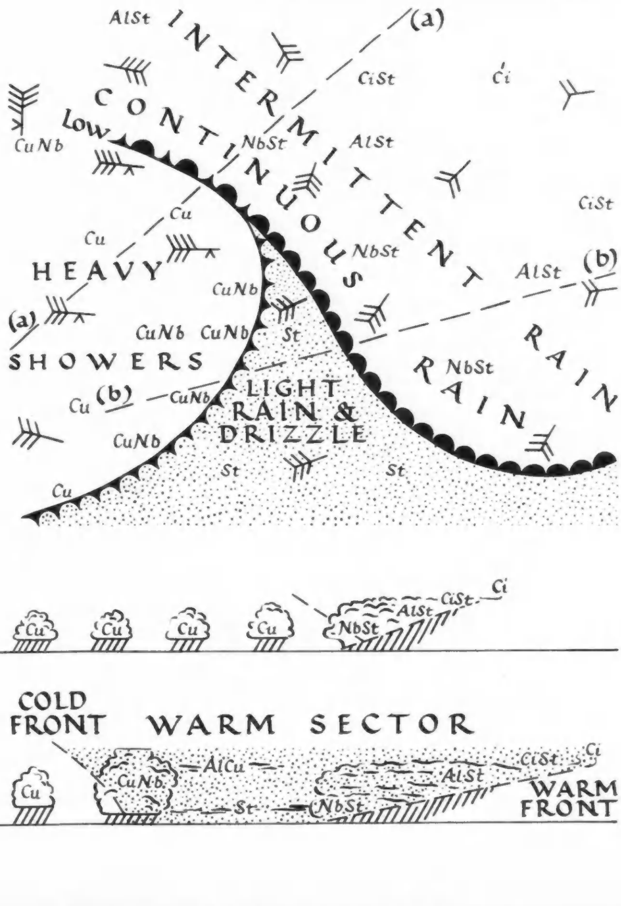


FIG. 3 (*right*).—*A Typical Partially Occluded Depression; (above) in plan; (below) sections along the lines indicated: through* (a) *the Occluded Front,* (b) *the Warm Sector.*

Symbols for fronts as in Fig. 4. Warm air shown dotted, precipitation shown by oblique lines. Abbreviations used for cloud types: Ci, *Cirrus;* CiSt, *Cirrostratus: both are High Cloud, base above 20,000 ft.* AlSt, *Altostratus;* AlCu, *Altocumulus: both are Medium Cloud, base 8000–20,000 ft.* Cu, *Cumulus (Shower Cloud);* CuNb, *Cumulonimbus (Thunder Cloud);* St, *Stratus;* NbSt, *Nimbostratus (Rain Cloud): all four are Low Cloud, base below 8000 ft.*

Arrows fly with the wind, the number of feathers denotes strength on Beaufort Scale. A V along the shaft means abnormally gusty wind varying around the Beaufort strength.

dense air originating over Greenland or the Polar icecaps, the two do not mix. Like oil and water, they are separated by a surface of discontinuity, called the Polar Front. The Polar Front often remains almost stationary for several days across the western Atlantic, usually somewhere between Newfoundland and Cape Hatteras. Sooner or later, a wave will form on the Front and commence to move along it in the direction of the upper winds, that is, to the eastwards or north-eastwards. As it moves the wave develops, with atmospheric pressure falling rapidly at the tip, and finally a depression is formed with the winds circulating counter-clockwise round the centre of lowest pressure. Such a depression will contain to the south of the centre a wedge of Tropical Air. The wedge is moving eastwards and the Tropical Air is therefore forced to rise over colder and denser surface air. As the moist air rises it is cooled adiabatically, the water vapour it contains is condensed into layer clouds from which, when they are thick enough, continuous rain will fall (Fig. 3). The forward limit of the Tropical Air is called a Warm Front. In the warm air behind this front, the Warm Sector, there is usually a lot of fairly thin cloud from which intermittent rain or drizzle falls, whilst fog is very liable to shroud windward-facing coasts and hills. The back of the wedge is marked by the Cold Front, where the denser Polar Air is vigorously undercutting the Tropical Air, but in a jerky fashion, so that the cloud types here are towering masses of heap clouds which produce thundery showers (Fig. 3). The Cold Front is always moving faster than the Warm Front, so that at the tip of the wedge the warm air is lifted off the surface and this part of the front is then said to be occluded (Fig. 3). The process of occlusion is a continuous one with the area of the Warm Sector steadily decreasing (Fig. 4). When occlusion is well advanced, the depression will commence to fill up and the vortex in the atmosphere will gradually disappear, though the presence of warm air at height will be shown by a steadily diminishing belt of rain-producing cloud. The life cycle of a typical depression from its birth as a wave on the Polar Front off Newfoundland, its passage across the British Isles as a partially occluded depression with usually a wide Warm Sector and its final disappearance over the mountains of Scandinavia as a dying occlusion usually occupies less than a week.

Conditions are not always favourable for the formation of waves on the Polar Front. A family of depressions will be born and they will travel eastwards to produce a week or so's very unsettled and stormy weather in the British Isles; then occurs an extra strong southward surge of Polar Air behind the last of the family; an anticyclone or a strong ridge of high pressure develops over the Atlantic and the weather type changes.

International Weather Ships

The forecaster is, therefore, particularly interested in watching for signs of depressions developing over the western

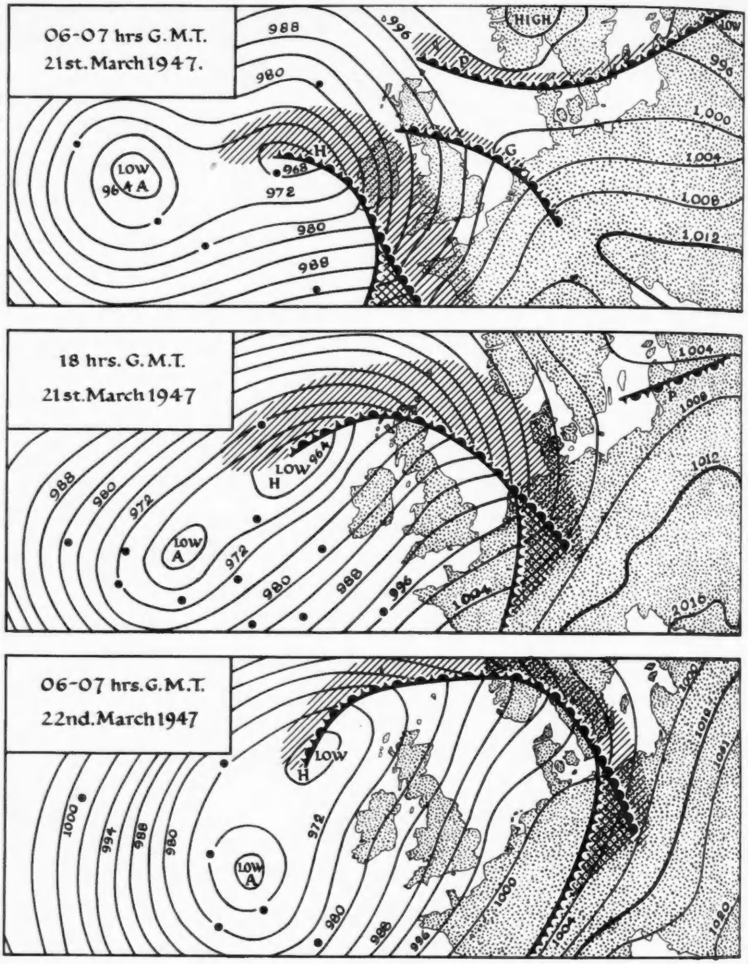


FIG. 4.—*Three consecutive Synoptic Charts illustrating the changes in weather during 24 hours as a frontal system moves across the British Isles.*

Curved lines are isobars (lines of equal pressure) with the pressure given in millibars. (Isobars are drawn at 4 millibar intervals.) The thickened line with half-circles marks a Warm Front; thickened line with teeth and half-circles marks Occluded Front. Cross hatching marks the Warm Sector; single hatching indicates the area of the rain belt ahead of the Warm Front and at the Occluded Fronts. There will be a belt of heavy showers at the Cold Front and light rain or drizzle in the Warm Sector. The small circles in the Atlantic mark the position of reports received from ships.

Chart 1. *A bundle of 'old' occlusions are producing narrow belts of rain over the North Sea and the Baltic. A vigorous frontal system, associated with secondary depression H, is affecting western Britain. Altostratus cloud will have reached London, heralding approach of the warm front.*

Chart 2. *Moving at about 35 m.p.h. over Scotland and 45 m.p.h. over England, the fronts have swept rapidly eastwards. The occluded part of the front H has increased considerably in length and the secondary depression H is rotating counterclockwise round the parent depression A. The central pressure of H has deepened from below 968 millibars to below 964. Occlusion P has become very feeble.*

Chart 3. *Depression H has begun to fill up, with central pressure above 964 mb. Its associated fronts are becoming feebler, with narrower rain belts, and are moving more slowly (about 25 m.p.h. in north and about 30 m.p.h. in south). An unstable airstream has spread across the British Isles behind the cold front and occlusion. Clouds will be of the cumuliform type.*

Atlantic. In the past he has had to rely on the reports from liners and aircraft moving along relatively narrow lanes. Sometimes he would receive many reports and would be able to analyse this part of the chart with confidence; at other times, reports would be few and he would sketch in his fronts and isobars with considerable uncertainty.

It is to remedy this that those nations most interested in weather conditions over the Atlantic have agreed to the establishment of thirteen International Meteorological Ships. These ships will not only carry highly trained observers for making the routine observations at the standard hours, but they will also be equipped with radar for the detection, up to a distance of many miles and under any weather conditions, of thick cloud masses. They also have radio-sondes for measuring the winds at height and the temperature and humidity stratification of the atmosphere. When these ships are all in place, as shown in Fig. 5, a fairly complete network of detailed reports will be received from the North Atlantic. The immediate outcome will be an improvement in the accuracy of forecasts for transatlantic flights and also, incidentally, those broadcast by the B.B.C. In a few years' time, when sufficient reports have been received, particularly about upper air conditions, invaluable material will be available for fundamental research. It is hoped that this research will produce as great an advance in our knowledge of the processes of the atmosphere, and hence in longer-term forecasting, as did the development of the frontal theory of depressions by the Norwegian meteorologists some twenty-five years ago.

Movement of Fronts

Once a depression or wave is detected or suspected the forecaster has to decide on its probable future direction and speed of movement and also how much it will develop. Depressions usually travel in a direction parallel to the run of the isobars in the Warm Sector and at a speed given by the Barometric Gradient or spacing of the isobars there. Clearly, if the drawing of the isobars round the centre of low pressure is incorrect, owing to insufficient reports, wrong conclusions will be drawn as to the future movement of the depression and its associated fronts and inaccurate forecasts will result. If the depression is deepening rapidly, the gradient between its centre and margin will be increasing and the fronts will be moving with increasing speed. If this tendency has not been detected, frontal rain may commence before the time forecast. Conversely if the depression is filling up, the gradient is slackening, it will be moving more slowly and rain mentioned in the forecast may not eventuate. An individual depression, moreover, is only one of a number of centres of high or low pressure shown on the chart; few of these will be stationary and nearly all will be either waxing or waning in importance. A depression may be deflected out of its anticipated path by a developing anticyclone or it may be drawn into the circulation of another and more vigorously deepening Low. All these are possibilities which the forecaster has to consider. Indeed his position is rather like that of a batsman trying to time a spinning cricket ball, which may come through easily or hang back or be a vicious top-spinner, a leg-break, an off-break or even a googlie. One particular depression which seemed to be following the usual track from off S.W. Ireland to between Scotland and the Faroes and then very unexpectedly swerved down the North Sea to bring heavy rain to S.E. England may be taken as a good example of a 'meteorological googlie'; it certainly bowled the forecaster all over his wicket as he had forecast fair conditions for S.E. England and did not issue an amendment until too late.

Not only has the forecaster to determine the probable movement of a depression and its fronts, but he has also to decide how vigorous are the fronts and how wide will be their associated rain-belts. All this will affect the timing of his forecasts of the commencement and cessation of rain in different areas. The answer will be partly given by his assessment of the difference in physical properties between the air masses separated by the fronts, but he must check it by watching the reports for frontal conditions beginning to affect a particular station, then for the passage of the Warm Front followed by the change into the humid conditions of the Warm Sector and then for the showers and gusts at the Cold Front. From his chart he can measure the width of the rain belt (see Fig. 4), while its speed of movement can be checked from the preceding charts and hence he can deduce the probable position of the rain belt 6 or 12 hours ahead. For aviation purposes, he must also consider the changes in wind, visibility, cloud height, thickness and amount, and in freezing level at the fronts.

Anticyclonic Conditions

The weather is not, however, always dominated by depressions and fronts. The intervening areas of high pressure, whether separate anticyclones or mere ridges of high pressure, present problems of their own, especially as regards visibility. The pressure gradient is then slack (see Fig. 6), winds are light and variable, and at night the sky is usually cloudless. The rapid cooling, under these conditions, by radiation to space, of the lowest layers of the atmosphere causes the relative humidity of the air to rise until the air is saturated. Any further cooling will then cause condensation of the water vapour either in the form of mist, fog or dew. Under such conditions there is usually a well-marked inversion of temperature, i.e. the temperature, instead of decreasing upwards with height, will increase up to a certain height, and then at the inversion the gradient changes to the customary decrease. If the inversion is well above the surface of the ground a thin sheet of layer cloud will often form just beneath it; this may produce, perhaps for days on end in the winter, the aptly named 'anticyclonic gloom', as the sun's rays are not sufficiently powerful to disperse the cloud. Beneath such an inversion, whether marked by cloud or not, the air is stable, and any particle of air displaced upwards or downwards will return to its former level as soon as the force causing movement ceases to act. As a result dust particles will be trapped beneath the inversion, for they cannot be dispersed upwards and can only move horizontally if there is sufficient wind. During a spell of quiet anticyclonic weather, smoke haze will therefore steadily thicken in industrial areas.

In the summer period anticyclonic weather is largely a time of relaxation for the forecaster. Early morning mist and fog will quickly be dispersed by the sun, for the warm air rising from the heated ground will soon break down the inversion. Apart from the haze in industrial areas, visibility will normally only cause trouble for a few hours around dawn. In the winter, though, it is a very different story, for visibility will then be the forecaster's main preoccupation.

In framing a forecast for a large area, only general terms can be used. It will be stated that the fog will be widespread or local, that it is expected to persist during the period of the forecast or that there will be a rapid or a slow improvement. For a particular place, however, the forecast is expected to be much more precise with the times when visibility is expected to fall below or improve above certain critical distances stated as accurately as possible. In a case like this the synoptic meteorologist has to adopt some of the methods of the 'local expert' and will have to consider very carefully topographic setting

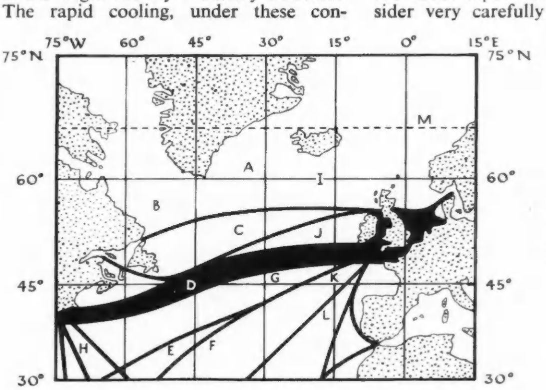
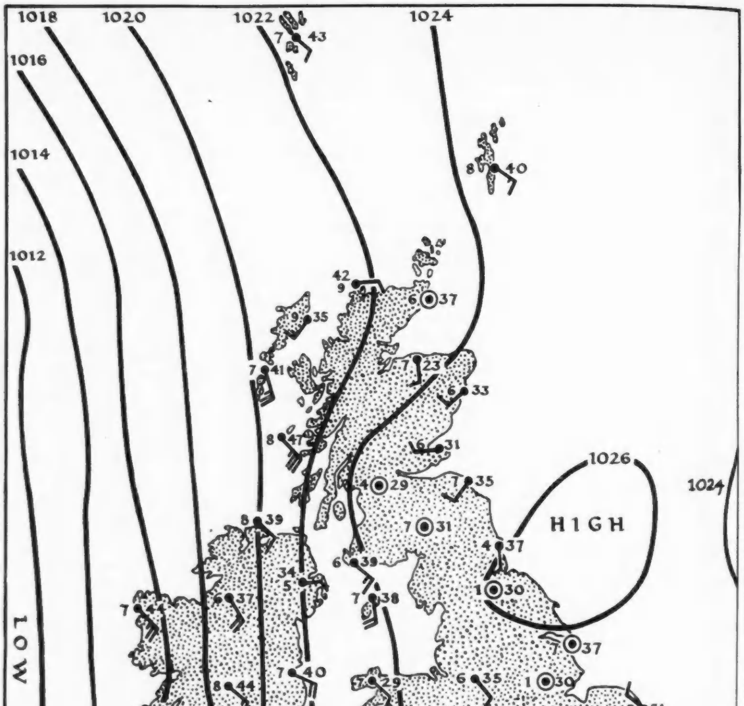


FIG. 5.—*Map of the North Atlantic showing the main shipping lanes and the stations of the thirteen international weather ships.*

and the proximity and direction of smoke sources. Anyone who has had occasion to cycle or motor regularly in the evenings over some particular stretch of slightly undulating road will have noted that fog or mist forms first and is densest either in the bottoms of the valleys and hollows or on the sides of hills, where a slight flattening of the slope forms a pocket in which cold air draining down from the higher ground can collect. The synoptic chart tells the forecaster that conditions are favourable for formation and by watching the recording instruments at his particular station he can make a fairly accurate estimate of the time of thick fog there, but the time that is given in his final forecast will be based largely on his past experience of similar conditions. He will have noted that when there was a light air drift from some particular direction, smoke-laden air from some factory or cold air flowing down a slight slope will have caused fog to form more quickly than when the air drift was from other directions.

When dealing with the clearance of fog, the meteorologist will consider whether the sun's rays will heat up the ground sufficiently for the inversion to be broken or, if slightly increased, air movement will help to disperse the dirt-laden air, or if a stream of drier air may spread across the area and absorb the fog. He will be anxiously watching his reports for any sign of improving conditions which may spread to his particular area.

During anticyclonic conditions in winter the forecaster will have other worries as well. Amongst other things night minimum temperatures must be forecast for frost warnings; here again local experience which subconsciously takes into account the differences in radiating powers of the various types of soil, as well as the possibility of the down-drainage of cold air, is of great value if only a small area has to be considered. He must be watchful of a front affecting the edge of the anticyclonic area. The risk then is of rain falling on frozen ground and producing glazed frost.



0600 hrs G.M.T 21st January 1947

FIG. 6.—*A simplified Synoptic Chart showing the eastern part of Great Britain under the influence of an anticyclone, whilst a warm moist southerly airstream covers the western half. Note differences in temperature and visibility between the two areas and the manner in which windspeed is approximately proportional to the barometric gradient, as shown by the spacing of the isobars. At each station visibility is shown by the figure to the left of the station circle, temperature in degrees Fahrenheit by the figures on the right; the arrows fly with the wind, speed on the Beaufort Scale being given by the number of feathers (circle means calm). The Visibility Code ranges from 0 (= less than 27 yds.) to 9 (= greater than 31 miles). The Beaufort Scale goes from 0 (0 m.p.h.) to 9 (47–54 m.p.h.).*

Thundery Conditions

There is another important type of weather which occurs on many days throughout the year. This is the type described in forecasts as 'showers and bright intervals' or 'cloudy with local thundery rain'. The former conditions are most typically found when a great mass of air streams southwards or south-eastwards across the British Isles after the passage of a vigorous depression. The forecaster knows that this air, originating in the Arctic regions and warmed in its lower levels by passing over the Atlantic, will be unstable and that powerful upward convection currents are probable. The sky will be characterised by cumulus or 'heap' clouds as distinct from the 'layer' or stratus clouds produced by the widespread ascent of air ahead of a warm front or beneath an inversion. If the cumulus clouds are thick enough they will produce showers, and if very thick they will develop into cumulonimbus or thunder clouds. The problem is to forecast the amount of sky that will be covered by these 'heap' clouds, the height of cloud base and cloud top, and hence if showers or thunderstorms will occur. The answer will be given by the tephigram, an intricate diagram devised by the late Sir Napier Shaw. On the tephigram, with its five different systems of coordinates, is plotted the information obtained either by radio-sonde or aircraft ascents as to the vertical variation of temperature, pressure and humidity. The tephigram shows that if surface temperatures reach a certain value, then convection will produce clouds of such and such thickness. The forecaster must decide if, later in the day, the critical temperatures will be passed.

More difficult usually are the 'outbreaks of rain of a thundery type'. These occur particularly in summer, when there is a thickness of unstable air at a considerable height. The presence of such a layer is suggested by reports of the turreted cloud technically known as altocumulus castellatus. Such layers will also be shown on the tephigram. Much work, however, remains to be done before these outbreaks are fully understood. Once such rain

commences, it is liable to spread very rapidly, for its movement is controlled by the winds at medium cloud levels, that is at perhaps 10,000 feet, and these winds may be very different in direction and speed from the surface wind.

When either showers or thundery rains are mentioned in the forecast it is impossible to say definitely whether a particular place will be affected. All that can be said is that widespread or local showers or rain will occur over a certain area. The path followed by the individual shower clouds cannot be forecast in advance, but again local experience is a help. Showers and thunderstorms are most likely to occur over areas where a combination of suitable soil and topography aids the ascent of air. Such localities can be indicated in a detailed forecast.

These are the main weather types, depressional, anticyclonic and unstable, with which the forecaster is confronted, but it must be emphasised that there are transitional as well as additional minor types. It is the transitional ones, particularly those without clearly defined fronts, but with a tendency towards instability, that usually present the most difficulty. The problem to be solved is, moreover, never one depending on only one variable. There are nearly always several possibilities and the difficulty is to detect in time the one which will temporarily dominate the weather situation.

A family of depressions may be succeeded by a large ridge of high pressure, causing a rapid change from unsettled to settled weather. Between each member of the family there has been a ridge of high pressure, but for some reason the ridges have never developed much; each has produced perhaps only 12 hours of fairer weather. For instance, it is difficult to read the signs that behind a depression just beginning to affect western Ireland is a ridge which will develop much more than the previous ones and that as a result there will be a complete change of type from depressional to anticyclonic weather.

It is clearly essential that the forecaster should have an adequate supply of reports and that the reporting stations should be dispersed as uniformly as possible over the area shown on his synoptic chart. Meteorology more than any other science depends on international co-operation. But surface observations must be supplemented by upper air soundings. One result of the war-time importance of Meteorology has been the development of new methods of obtaining data about the upper air and the establishment of additional upper air stations. The area from which reports are of critical importance will change from day to day, but more often than not for the western European forecaster it will lie over some part of the North Atlantic, hence the importance of the meteorological ships.

READING LIST

A useful general introductory book on Meteorology is Prof. D. Brunt's *Weather Study* in Nelson's Aeroscience Manuals. A recent authoritative account of the work of the Forecast Division of the Meteorological Office is *Here is the Weather Forecast* by E. G. Bilham, 1947, Golden Galley Press.

The Meteorological Office, Victory House, Kingsway, W.C.2, issue daily a *Daily Weather Report*, containing synoptic charts of the Northern Hemisphere and the British Isles together with reports at 6-hourly intervals from over 70 stations in the British Isles. Upper Air and International Sections are also available.

FISH MIGRATION—*continued from p. 185*

and Bermuda, and it was concluded that here, but at a greater depth, was the breeding area.

American eels, which are of a different species, breed in an area overlapping that used by the European eels, but centred farther to the west. Mediterranean eels, which are of the European species, breed in the Mediterranean as well as in the Atlantic.

The spawning season lasts from early spring until summer. At about this time tiny larvae of only 5 to 15 mm. length, perfectly transparent, appear at a depth of 100 to 300 metres. During the following three summers they move slowly across the Atlantic, feeding on plankton and growing to a length of 7·5 cm. After the third summer the Leptocephali undergo a transformation. The feeding stops, the body becomes narrower and gradually shorter, the animal becomes pigmented and its blood becomes visibly red. The larvae thus change into young elvers, which commence to feed and soon begin their ascent of the rivers as their parents did before them.

The migration of the eel, which until recently had seemed difficult to explain, has been reviewed in a thorough study by Professor L. Bertin of Paris. In his view, the eel should primarily be regarded as a deep-water fish, and the successive stages which have been identified in the development of elvers to eels would in themselves suggest an evolutionary history of unusual complication. The elvers in their first phase are sexually neutral, but in the following two phases they show a sexual development of purely temporary character. In the second phase (in which they grow from about 14 to 18 cm.) there is a "transitory and precocious development of female characteristics". In the third phase, there is a hermaphrodite development with the beginnings of egg and sperm formation in the same organ. This covers the age period of 5 to 8 years, in which time the length increases from 18 to 30 cm. Two or three years are allowed for the pre-elver stages, and two more years pass before scales begin to form. The scales themselves show a fine structure, with each summer's growth represented by a ring of calcareous buttons—analogous to tree rings—from which the age of the eel can be deduced.

The final transition is one long recognised by fishermen—the change from the 'yellow' eels of river life to the 'silver' eels which are sexually mature and ready for their breeding migration. The eyes are now larger, the body plumper, the pectoral fins longer and more pointed, and both back and fins darker in colour. The sexual organs are more developed; the digestive tract has shrunk and feeding is reduced. In the male, the transition comes usually at 8 to 14 years; but the female, which grows to a greater length, takes from 2 to 4 years longer.

The first stage in the urge to migration is represented by a change in the reaction of the eels to contact with solid objects. Instead of creeping along the bottom of rivers, their instinct is now to get away from the bottom and swim freely. Prof. Bertin came to the conclusion that the three thousand miles breeding migration of eels from the Atlantic coast of Europe to an area south-east of the Bermudas can be physically explained. He lists three further stimuli, the first of which is their reaction to moving water. This is passive rather than active, so that they are carried with the flow towards the sea.

A second stimulus, which is of more lasting importance in migration, is their reaction to heat. Eels prefer warmer water, and show more reaction in summer than winter. Such a response, Prof. Bertin points out, would take the majority of European eels from the continental shelf west of Ireland and Spain to the region which is their breeding ground. From this point of view, the 'eel-bridge' traced by Schmidt can be regarded rather as a ditch or basin of progressively warmer water.

The importance of temperature as a stimulus is supported by the fact that the breeding area is fairly closely defined as that region in which the temperature is between 16° and 17° C. The depth at which mating takes place is limited to about 400 metres, for the warm basin extends no deeper.

The third reaction which Prof. Bertin regards as important is that of avoidance of light. Migrating eels prefer night to day while in shallow water, and as soon as possible seek depth for darkness. Hence the small probability that they will be caught during ocean migration.

Prof. Bertin also suggested how the developing larvae are brought nearer to the surface.

There is no information as yet of the mature and fertilised eggs, nor will this information be easy to come by. But in the earliest larvae there is an oil drop, which is less dense than water, contained in a small sac which is regarded as a survival from the egg. This would give the fertilised egg some initial buoyancy. In confirmation of his hypothesis, Prof. Bertin points out that both in the hermaphrodite phase, and later in the immature eggs of the female, there are traces of apparently similar oil in the sex organs.

An implication is that the oil drop mechanism goes back some considerable distance in the evolution of the species—which supports Prof. Bertin's general conclusion that the eel is essentially a deep-sea fish. So also does the fact that the eel is well designed physically to resist pressure.

Far and Near

Joliot-Curie Dismissed

On April 28 the French Government announced its dismissal of Frédéric Joliot-Curie from his post as High Commissioner of Atomic Energy (which is approximately equivalent to that of Sir John Cockroft in Britain). According to *The Times*, this action of the French Government is interpreted as the prelude to firm measures against Communist agitation. At a recent Communist congress, Joliot-Curie said that "progressive and Communist scientists would never yield a fraction of their knowledge to make war on the Soviet Union". During his term of office the possible danger that might arise through conflict between Joliot-Curie's loyalty to the Commission for Atomic Energy and to the Communist Party had been widely discussed in the Press on many occasions, as for instance the occasion in January 1949 when he told a Press Conference in Paris that he was a Frenchman first and that his official position would make it unthinkable for him to deal with any foreign power. This was followed by the report that the French Communists had disavowed. At the time one paper commented that Joliot-Curie "is a disloyal Communist if he doesn't tell secrets and he is a disloyal Frenchman if he does. Only if France should go Communist will he be relieved of his dilemma." The French Government has found another way to put him out of his dilemma, but in the process has lost the services of a brilliant scientist who will be difficult to replace.

The Purge in Britain

The British Atomic Scientists' Association issued in April a statement on "the Civil Service purge of persons who are members of extremist political organisations and likely to weaken national security". This expressed misgivings about the effects of the measure. It admitted that opinion within the A.S.A. Council is divided on the issue. Some Council members consider that it is an unpleasant necessity forced on the Government by a situation that could not be dealt with in any other way, others that the measures (explained by the Prime Minister in Parliament on March 15, 1948) establish a dangerous precedent that allows persons to be penalised for associations not prescribed by law.

The statement went on, "There is, however, a widespread and general consensus of opinion that the application of the considerations and procedures which operate in establishments governed by the security regulations should, at all costs, be prevented from being extended to other institutions. It is difficult to avoid the conclusion that even in friendly countries, individuals employed in universities and in industry have been penalised on political grounds. Whilst the most important effect of these actions on the development of science and the advancement of knowledge will not appear until after a considerable lapse of time, the experience of other countries strongly suggests that it can be very serious and even disastrous. Men of proved ability and distinction are replaced by others of lesser attainments who have the recommendation of political conformity. At a time when the need for scientists is so great and the supply of competent men so inadequate, similar measures in this country would be likely to produce a rapid and progressive decay in professional standards; a poisoning of the relationships between colleagues in the same institutions; and a serious change for the worse in the intellectual atmosphere of our schools and universities to the great detriment of coming generations."

The statement refers to the Fuchs case (Discovery, April 1950, p. 133), but expresses the doubt whether any measures based on political association would give any protection from further cases of this kind.

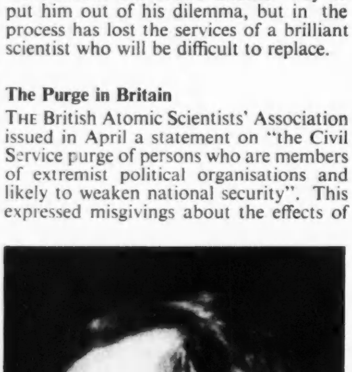
New Director for Geological Survey

Professor William John Pugh, professor of Geology at Manchester University takes over the direction of the Geological Survey and Museum from Dr. W. F. P. McLintock who is retiring this autumn.

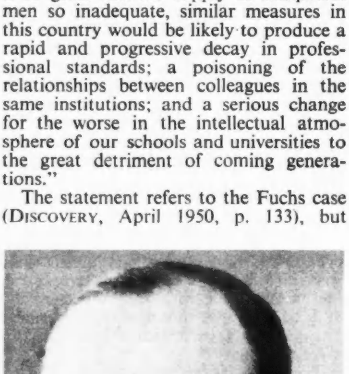
Radio Progress

A recent exhibition organised by the Radio and Electronic Component Manufacturers' Federation in London demonstrated notable progress from the anxious days of last year when the hysterical post-war sellers' market had collapsed. Two trends were outstanding, namely greater reliability and stability, and the 'miniaturisation' of components.

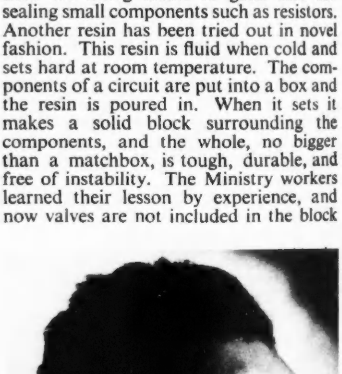
The first trend was quite general. Purely qualitative and vague description is no longer enough; hours of life, tolerances, and methods of testing are given even in the sales data. One way of producing stability is the sealing of components to keep them away from the air. The Ministry of Supply, for example, demonstrated two synthetic resins used for this purpose. One is Araldite, which can be used for fixing metal to glass and for sealing small components such as resistors. Another resin has been tried out in novel fashion. This resin is fluid when cold and sets hard at room temperature. The components of a circuit are put into a box and the resin is poured in. When it sets it makes a solid block surrounding the components, and the whole, no bigger than a matchbox, is tough, durable, and free of instability. The Ministry workers learned their lesson by experience, and now valves are not included in the block



Dismissed from his post as France's High Commissioner for Atomic Energy, Frédéric Joliot-Curie.



Appointed director of the Geological Survey and Museum, Prof. W. J. Pugh, geology professor at Manchester.



Appointed director of the National Coal Board's Central Research Establishment, nr. Cheltenham, Dr. J. Bronowski.

setting, for they are the weakest members of the assembly in that they have limited lives; so they are now mounted outside the block, and can thus be replaced. The Ministry's demonstration showed several assemblies of one circuit. Each of these circuits was seen to give equally reliable results, even though the 'encapsulated' circuit was only a fraction of the size of the normal circuit with valves mounted in the usual way on a chassis. One of the demonstrated circuits was 'printed'. That is to say, the connecting 'wires' consisted of lines printed with an ink made of colloidal metal, and the resistors were lines painted on with graphite. This method of construction has great advantages in the saving of space, though not of time, for components such as resistors have each to be adjusted in value after the printing. Nevertheless, the notion that a radar set will be at some future time 'papered' on the wall of an aircraft is not as fantastic as it sounds.

Striking improvements in materials during the past years, and ingenious developments in production jigs and methods have helped in the trend towards smaller components. This applies to rectifiers, potentiometers (some now weighing a twentieth of an ounce each), switches, transformers, and a number of other components, but especially valves. Every valve manufacturer has now a range of miniatures of such a size that the term 'acorn valve' is no longer applicable. Mullard in particular exhibited sub-miniature output pentodes taking only just over a volt for the filament and consuming in it only twenty-five milliamperes. The filament of such a valve is finer than a hair and three of them can be accommodated in an ordinary thimble. These valves are expressly intended for deaf-aid apparatus. One of them can give nearly twenty milliwatts of power with a high-tension voltage of only forty-five

Night Sky in June

The Moon.—New moon occurs on June 15d 15h 53m, U.T., and full moon on June 29d 19h 58m. The following conjunctions with the moon take place:

June					
6d 17h	Jupiter in conjunction with the moon,	,,	Jupiter	2°	N.
12d 08h	Venus	,,	Venus	6°	S.
13d 17h	Mercury	,,	Mercury	8°	S.
21d 23h	Saturn	,,	Saturn	0·4°	N.
23d 11h	Mars	,,	Mars	0·4°	N.

The Planets.—Mercury is too close to the sun for favourable observation; the planet rises about three-quarters of an hour before the sun, from the middle to the end of the month, but will be lost in the twilight. Venus, a morning star, rises at 2h 30m, 2h 10m, and 1h 55m, at the beginning, middle, and end of the month respectively, the corresponding times for the sun being 3h 50m, 3h 40m, and 3h 45m, so the planet can be seen for a short period before sunrise. After June 10 more than three-fourths of the illuminated disk is visible, and the stellar magnitude of the planet remains almost the same, at about -3·4, though its distance from the sun varies from 100 to 118 millions of miles during the month. Mars is visible until the early morning hours, setting at 1h 20m, 0h 27m, and 23h 41m, at the beginning, middle, and end of the month, respectively, its stellar magnitude varying from 0·2 to 0·6, and its distances from the earth between 90 and 109 millions of miles. Jupiter rises just before midnight in the middle of June, and at 23h on June 30. The planet can be seen as a star of magnitude -2·1, or more than 2½ magnitudes brighter than Mars, in the constellation of Aquarius. Notice that it is stationary on June 27, after which it has a westerly movement amongst the stars, but this will scarcely be noticeable until a week or more later. Saturn sets shortly before Mars, and is easily recognised a little west of σ Leonis to which it draws slightly closer during its apparent easterly movement. Notice how close Saturn is to the moon on June 23; a little before the moon sets the planet is less than half a degree north of the moon. Summer solstice takes place on June 22d 00h, and on this day the sun rises at 3h 42m, and sets at 20h 21m in the latitude of Greenwich (no notice is taken of summer time in any of the computations), and if we were in latitude 60° N. the corresponding times would be 2h 35m and 21h 28m, which implies about 2¼ hours more daylight in the latter place. At places in latitude 66½° there would be neither sunrise nor sunset, the sun remaining above the horizon all day, though it would just skim it at midnight, but owing to twilight there would be no darkness, even when the sun set for a short time some weeks later. The short nights during June make conditions rather unfavourable for observation of the heavens.

Fair Copy?

If imitation is the sincerest form of flattery, then Discovery does not seem to lack for admirers. There was, for instance, the Greek popular science journal which modelled itself so closely upon our journal that it even took over our cover design so that at first glance one might have thought that one was looking at a Greek edition of Discovery; there was no real difference between the covers of the two journals beyond the difference in title. We have become used to such things, and so we were not altogether surprised that the science supplement which *The Times* produced this April was advertised under the title "The Progress of Science", familiar to our readers as the heading to our monthly notebook.

An International Research Project

A remarkable example of international scientific collaboration is provided by the group of physicists of France, Holland and Great Britain, to be joined later by a Swedish scientist, who are co-operating in an investigation of the factors affecting luminous flame radiation, using an experimental furnace in the Royal Dutch Steel-works at Ijmuiden, Holland. Out of this work are certain to come findings of great practical importance to designers of furnaces, and information should also become available as to the most efficient use of different kinds of furnace fuels. The work is supervised by committees set up in each country, the respective chairmen being Prof. G. M. Ribaud, J. E. de Graaf and Prof. O. A. Saunders. There is a co-ordinating committee with Prof. Ribaud as Chairman and P.A.H. Elliot as Secretary. Any organisation or firm wishing for further information about the project should write to: The Secretary, Flame Radiation Research British Committee, c/o B.I.S.R.A., Physics Laboratories, 140, Battersea Park Road, London, S.W.11.

D.S.I.R.: Advisory Council's New Chairman

Professor Sir Ian Heilbron, F.R.S. becomes Chairman of the Advisory Council for Scientific and Industrial Research in the place of Sir Geoffrey Heyworth, who has resigned owing to pressure of other public duties. The Advisory Council for Scientific and Industrial Research is composed of persons eminent in industry and science, and its task is to advise the Lord President of the Council on the policy and activities of the D.S.I.R. Sir Ian is the Research Director of the Brewing Industry Research Foundation, which is concerned with the problems of the fermentation industries.

His predecessors as chairmen of the Advisory Council were Sir William McCormick, F.R.S., Professor V. H. Blackman, F.R.S., Lord Rutherford, F.R.S., Lord Riverdale and Sir Geoffrey Heyworth.

Building Research Congress

A scientific congress timed to take place so that visitors to it can visit the Festival of Britain is announced. This is the Building Research Congress to be held in London, September 11–20, 1951. The first of its kind ever to be held, it will mark the rapid developments in building science made since the end of the war. Particulars can be obtained from the Congress's Organising Secretary, Building Research Station, Garston, Watford, Herts.

Paralysing Nerve Gases

Major-General Anthony C. McAuliffe, Chief of the Army Chemical Corps, told the American Chemical Society at a meeting in Detroit last month that the United States had developed or was developing 'nerve' gases that could without bloodshed paralyse the will of an enemy to resist, and "thereby obtain a victory without the enormous destruction of his economy". He said the United States would never take the lead in using such weapons, but would retaliate with them if they were used by others. He also said it must be assumed that America was not the sole possessor of the offensive and defensive secrets of the new gases, as Russia is exploiting the knowledge of many German experts on chemical warfare.

Rubber Research Centre

THE largest Rubber Research Centre in the British Commonwealth is being opened at Fort Dunlop on June 7 by Sir Lawrence Bragg.

List of Research Journals

CAMBRIDGE University Press has published for the Royal Society a half-crown booklet entitled: *A List of British Scientific Publications Reporting Original Work or Critical Reviews*. This will be found useful to any person who needs a good guide to the science journals which publish a significant proportion of original work.

Hydraulics Research Station

A NEW hydraulics research station is to be established by the D.S.I.R. in Howbery Park, an estate of 90 acres on the Oxford Bank of the Thames upstream from Wallingford Bridge. One of the first pieces of apparatus scheduled for construction there will be a wave tank in the open, 250 ft. long by 160 ft. wide and 2½ ft. deep, in which coast erosion and wave problems will be studied. The Director of Hydraulics Research is Sir Claude Inglis, who was formerly Director of the big Central Irrigation and Hydrodynamic Research Station at Khadakvasla, near Poona.

A New Form of Carbon

THE recent announcement of a new form of carbon, known as Delanium, now in commercial production, has considerable technical interest. Up to the present, the use of carbon as an engineering material has been restricted in spite of its good physical, chemical and thermal properties, by its mechanical weakness. This defect has been the result of the classical process used in the production of industrial carbon. The method involves two constituents—the ground carbon, and binder—and hence on carbonisation gives a heterogeneous structure, which is inherently weak, and its porous nature is an added disadvantage.

Powell Duffryn Research Laboratories, approaching this problem from a fundamentally different angle, have developed a carbon with a homogeneous structure.

The Delanium process produces carbon directly from the type of coal which is self-agglutinating. The method is essentially that of coking, but the appearance of the characteristic irregular honeycomb structure of coke is prevented by the close control of firing rates, and the use of small quantities of chemicals that inhibit 'swelling'. The new carbon is homogeneous and of low porosity, in contrast to other forms of commercial carbon.

Delanium can be produced to meet particular requirements as regards mechanical strength, density, chemical resistance, permeability to liquids and gases, thermal and electrical conductivity. It can be moulded into rods, bars, tubes, blocks, containers, and other shapes suitable for particular applications.

The chemical resistance and high impermeability of Delanium, together with its mechanical strength, make it particularly useful for plant coming in contact with corrosive chemicals. For instance, tiles have been made for vat linings, which compare favourably with ceramic materials. Its use solves many problems which have up to now been intractable, for example, the handling of dilute hydrofluoric acid at high temperatures, and the recovery of heat from paper pulp waste liquor. It is clear that new fields are now open to carbon as a chemical engineering material.

'Zebra' Pedestrian Crossings

IN London and provincial towns the Road Research Laboratory has been watching the reaction of the public to the new black-and-white 'Zebra' pedestrian crossing. Results show that the Zebra marking has a very favourable effect on the behaviour of both pedestrians and motorists. The investigation was put in hand after tests on models at the Road Research Laboratory had shown that of all possible forms of marking road surfaces the pattern most easily visible to the motorist was one consisting of alternate black and white stripes laid parallel to the kerb. It was thought that if crossings could be made more conspicuous to motorists two beneficial results might follow: pedestrians would be encouraged to make better use of the crossings and motorists would be more ready to give way to pedestrians using them.

The movements of pedestrians and motorists have been observed at 25 Zebra crossings, and at an equal number of ordinary crossings marked by studs and beacons.

The effect of the Zebra marking on road accidents is also under study, about 1000 crossings in different parts of the country were marked with the Zebra pattern, and the records of accidents before and after the change were studied. The data so far obtained are insufficient to lead to reliable conclusions; experience of a still larger number of crossings would be necessary to provide a complete answer.

Voyage of Discovery II

AT the beginning of May *Discovery II* left Plymouth on a voyage of deep-sea research to the Southern Ocean and Antarctic which will last nearly two years. This vessel and the smaller research vessel, the *William Scoresby*, belong to the National Institute of Oceanography. This oceanographical research was formerly the responsibility of the Discovery Investigations Committee, set up by the Colonial Office in 1924.

Discovery II is an oil-burning ship of 1036 tons, carrying comprehensive equipment for deep-sea research. Besides the complement of about 48 officers and men she carries four scientific officers and three assistants. In charge of the scientific work is Dr. H. F. P. Herdman, and Commander J. F. Blackburn, R.N. is in command.

The purpose of the voyage is to complete an oceanographical survey of the Southern Ocean started by the Discovery Committee before the war. As the ship progresses, first south from Colombo, then from Freemantle southwards through the Indian Ocean to the pack-ice and eastwards to various points between Australia, New Zealand and the Antarctic, she will be stopped at intervals for deep-sea investigations to be made. Samples of the ocean bed will be taken with a piston core sampler similar to that designed by Dr. Kullenberg, and used on the *Albatross* expedition. Water samples will be taken from the surface to a depth of about 1500 metres, and examined for its plankton content. From observations of the plankton it is hoped that new light will be shed on the distribution of whales that feed on plankton. The *Discovery* researches have given much new knowledge about whales; for instance, they revealed that the long accepted view that whales reached their huge size by slow growth was contrary to the time facts. Special thermometers will enable temperatures to be taken at any depth up to 3000 fathoms.

Echo soundings will be made on two recorders—one which records in depths up to 2250 fathoms, and the other which is for use in shallower water. The southern part of the Indian Ocean is still relatively unknown, and few depth soundings have been recorded; the new soundings will enable the Hydrographic Department of the Admiralty to correct and extend their charts.

Associations of Science Writers

THE Division for the Popularisation of Science in the Natural Sciences Department of Unesco is intimately concerned with the fostering of associations of science writers. Such organisations have been formed, during the past few months, in Denmark and Austria. The secretary of the Danish Science Writers' Association is Sven Alkaersig, Radiohuset, Copenhagen V; and of the Austrian, Dr. Norbert Grell, Kandlgasse 35/17, Vienna VII. Recently, a committee was set up to examine the situation in Holland; and in France a number of science writers is now actively preparing a draft constitution which is to be presented at a meeting to be held shortly. From India and from Italy have also come requests for assistance in the formation of science writers' associations. It is hoped eventually to set up an International Federation of Science Writers' Associations which would link these bodies with the National Association of Science Writers (U.S.A.) and the Association of British Science Writers. Assistance in the development of such associations in any country can be obtained on writing to the Natural Sciences Department of Unesco, 19, Avenue Kléber, Paris.

The Reith Lectures 1950

THE B.B.C.'s Reith Lectures this year will be given by PROFESSOR J. Z. YOUNG, F.R.S., Professor of Anatomy at University College, London, on the subject of "Doubt and Certainty in Science".

SIR HENRY DALE has been appointed adviser to the B.B.C. on scientific programmes, for a year beginning July 1. He will give advice on the content and co-ordination of broadcast talks on science and will also examine the possibilities of developing scientific programmes for television.

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. Editorial Offices: 244 High Holborn, W.C.1.

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